THE INSTITUTION OF PRODUCTION ENGINEERS JOURNAL

DECEMBER 1956

THE INSTITUTION OF

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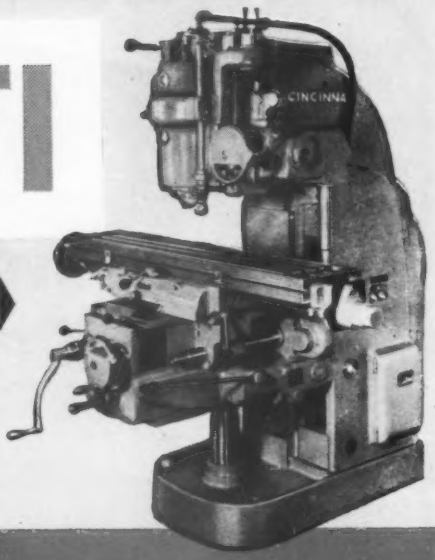

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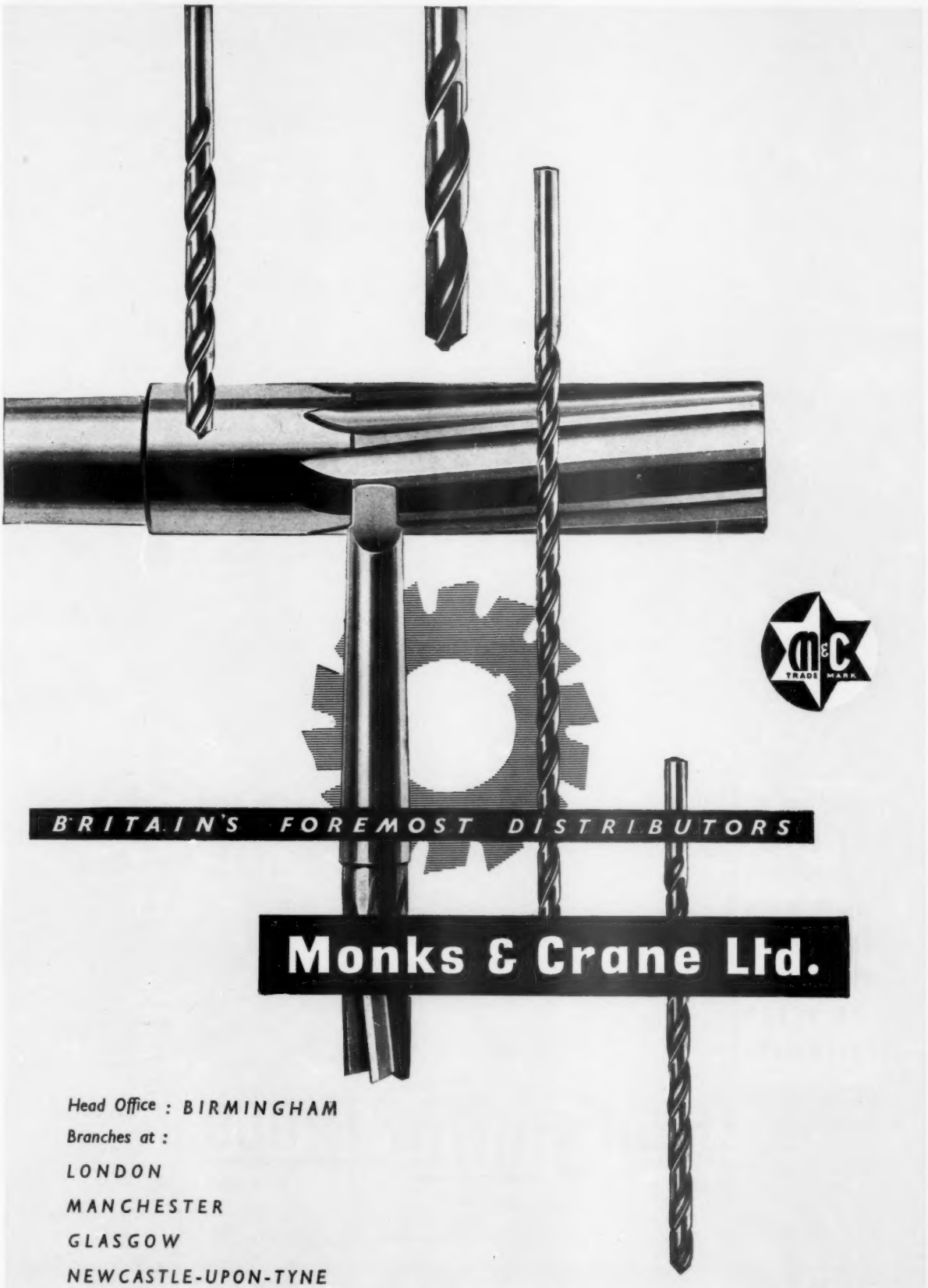
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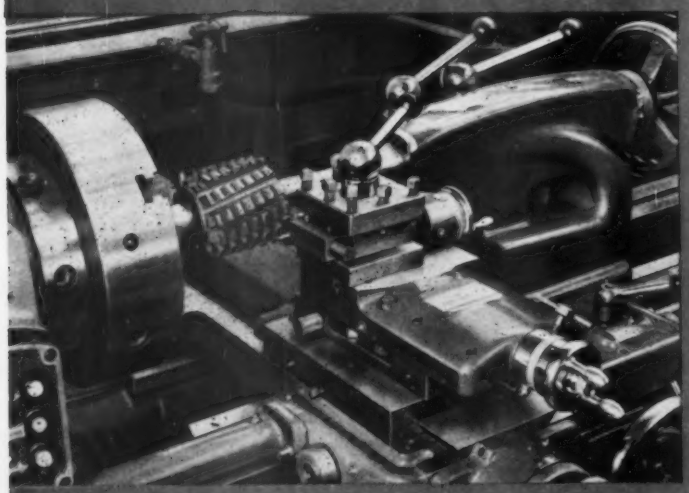

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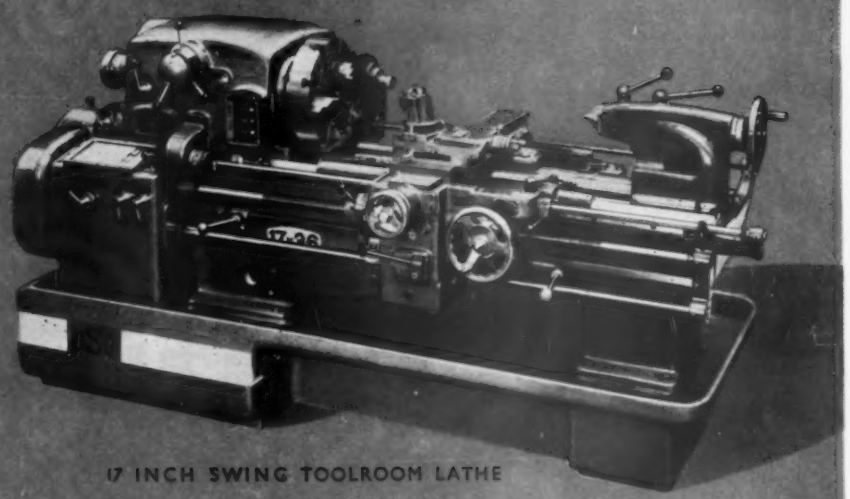

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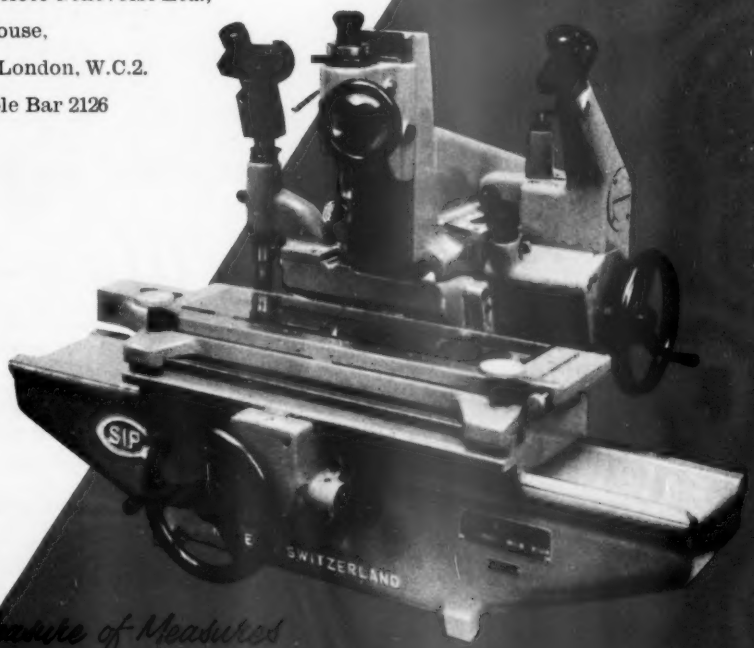

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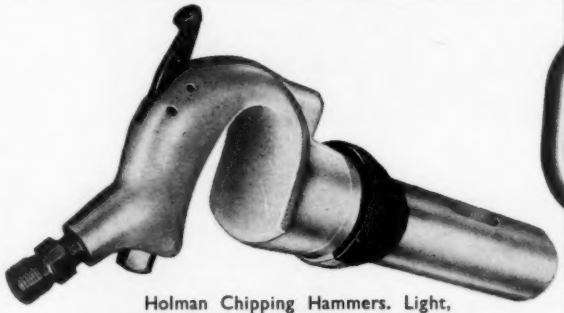

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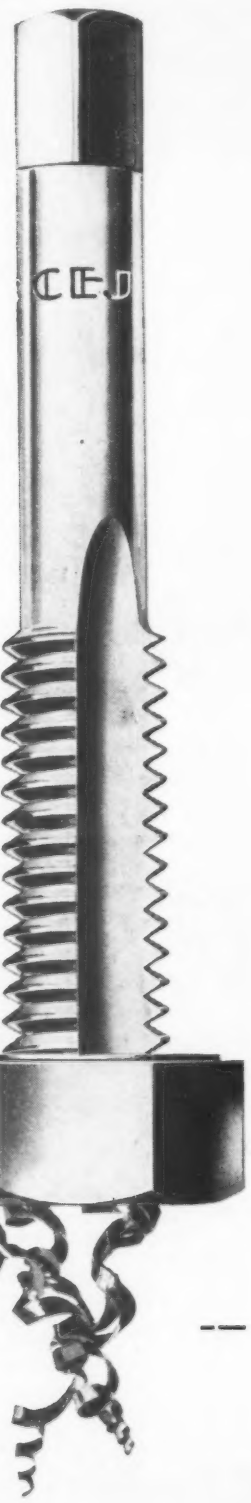

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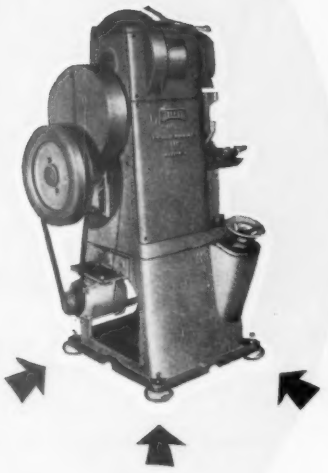

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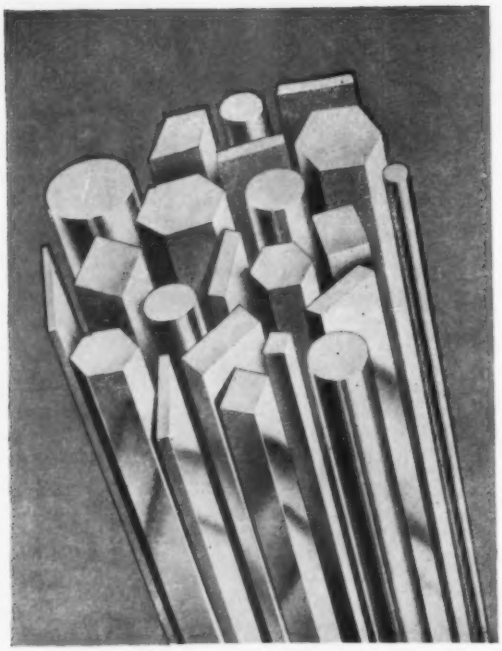

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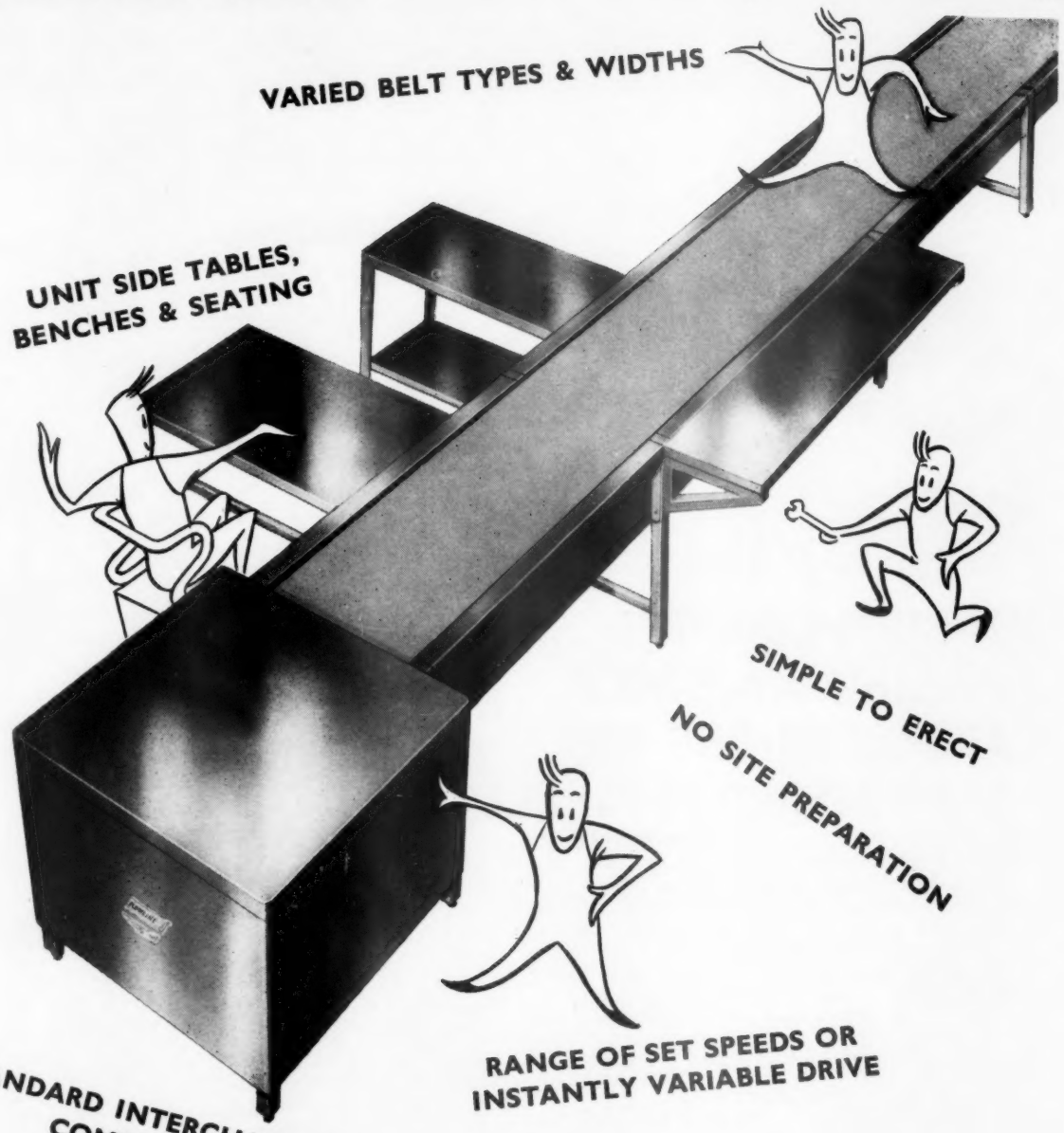
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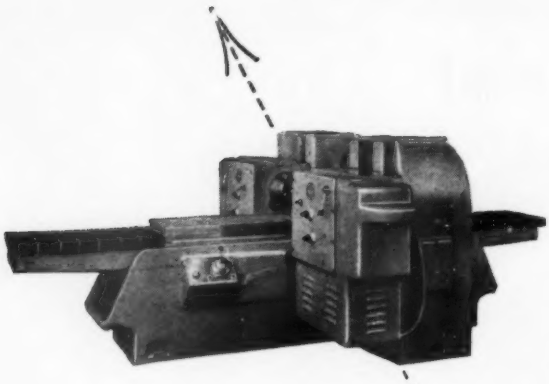

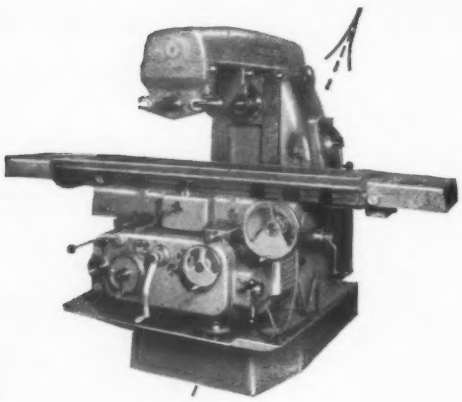

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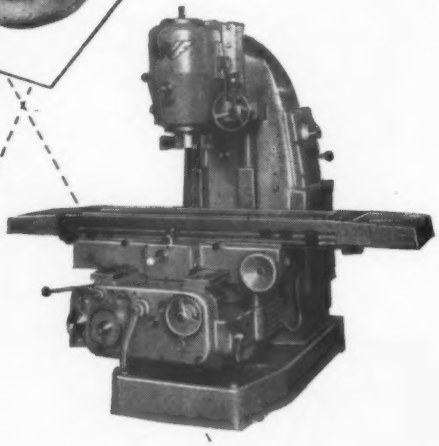

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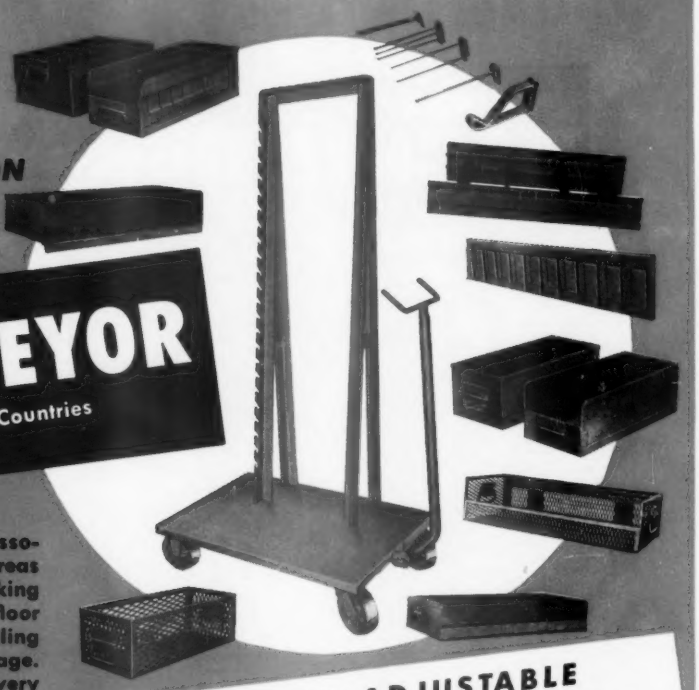

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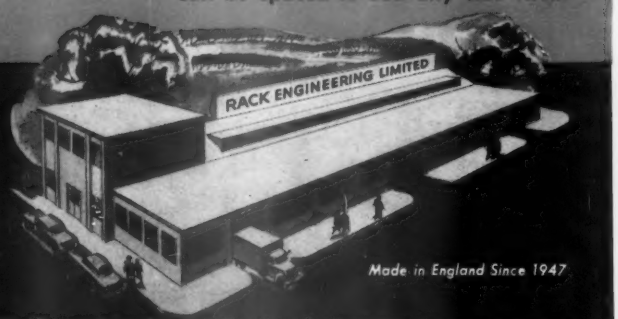

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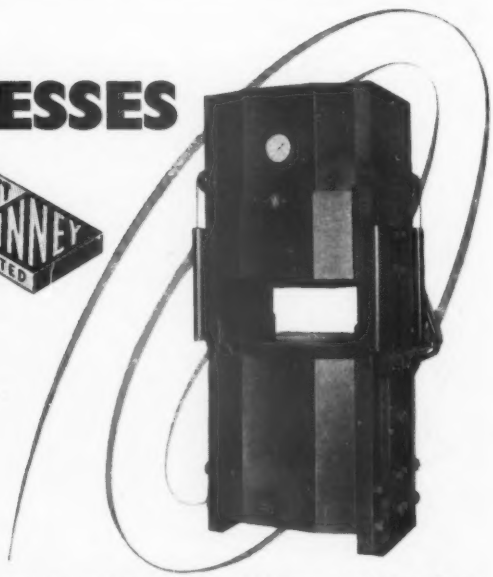

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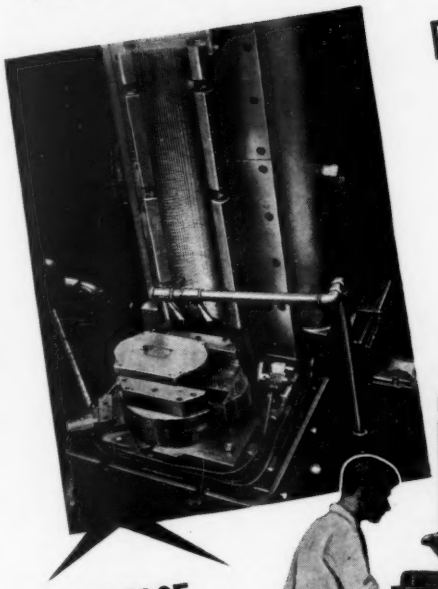

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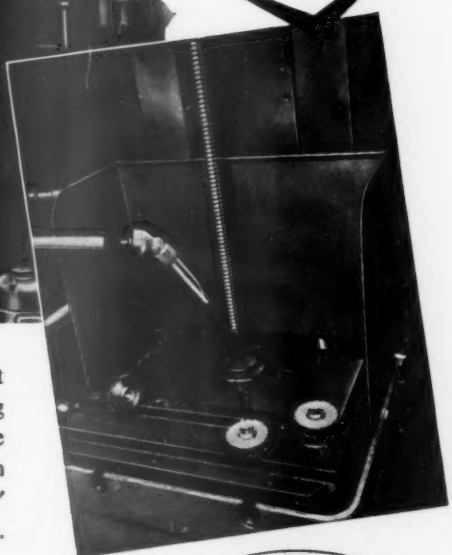

Illustration shows 2 identical machines which are used for internal OR surface broaching as the type of work necessitates. "Change-over" is a simple operation.

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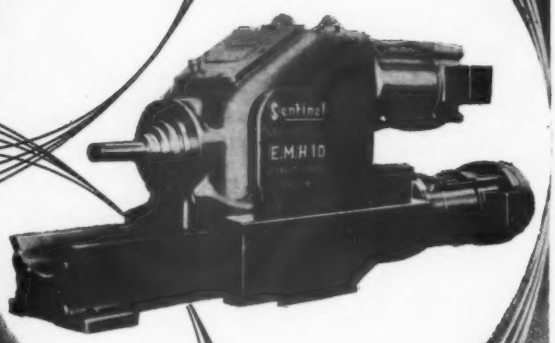

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Sogenique (Service) Ltd.

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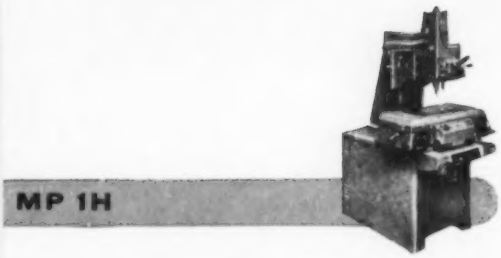
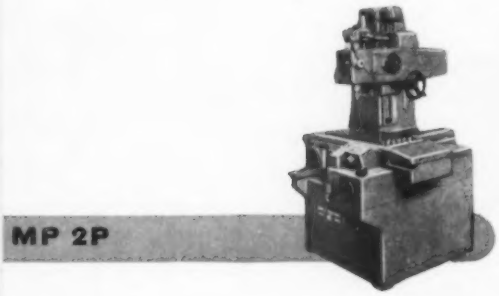
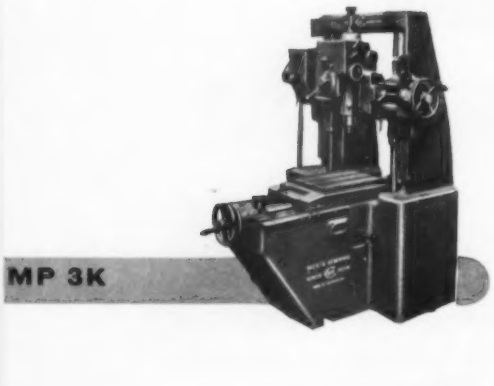


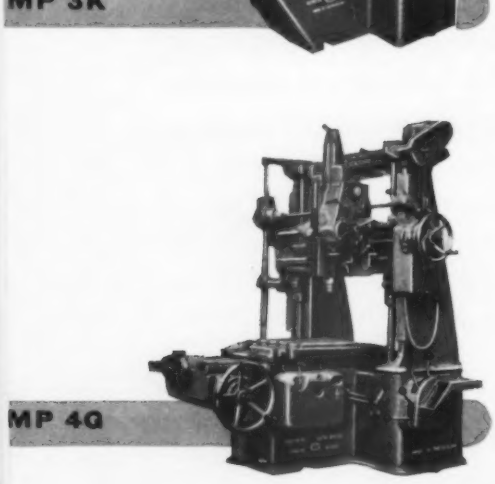
MP 1H



MP 2P



MP 3K



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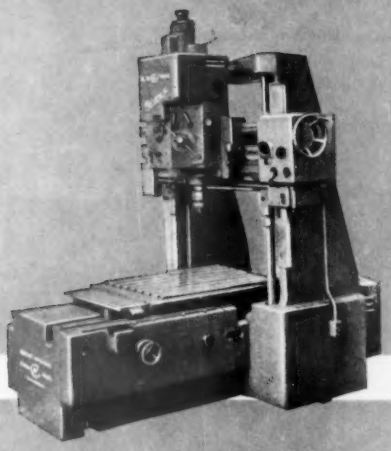
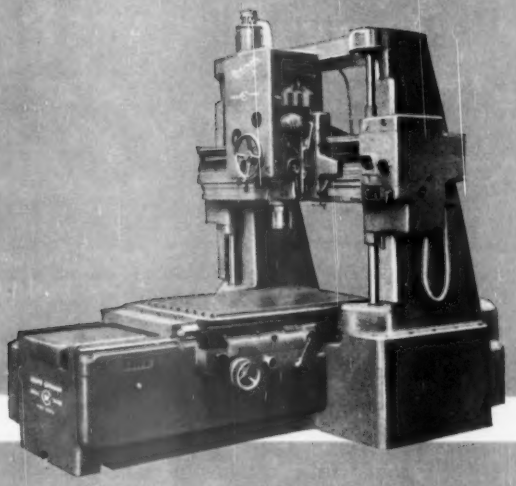


HYDROPTIC 6



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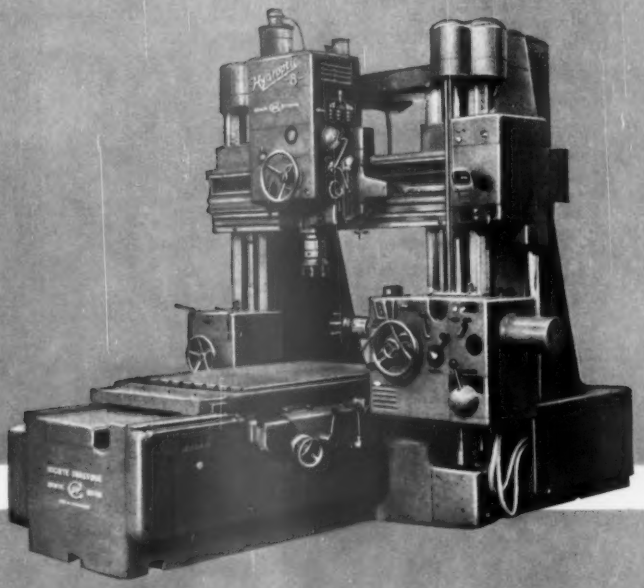

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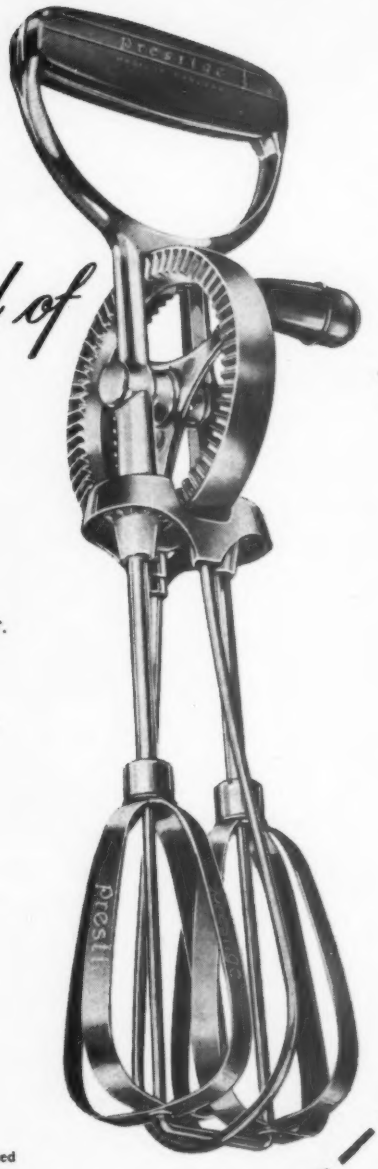

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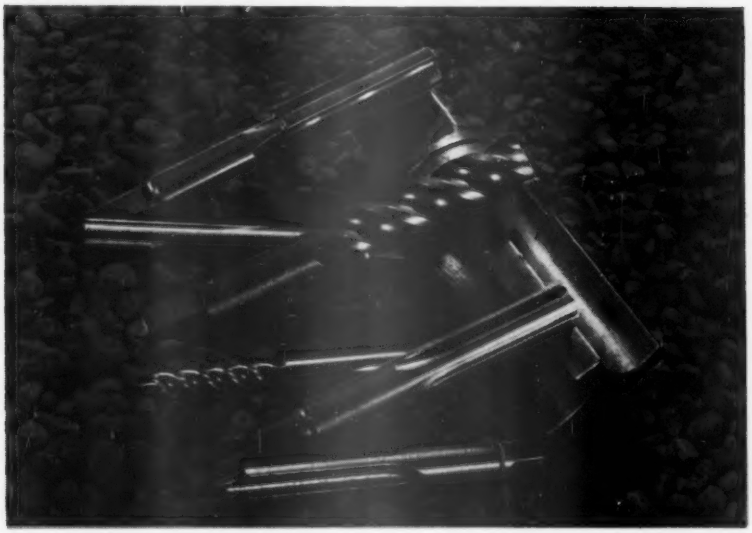
A selection of small tools which have been barrelled with ALOXITE *tumbling nuggets*



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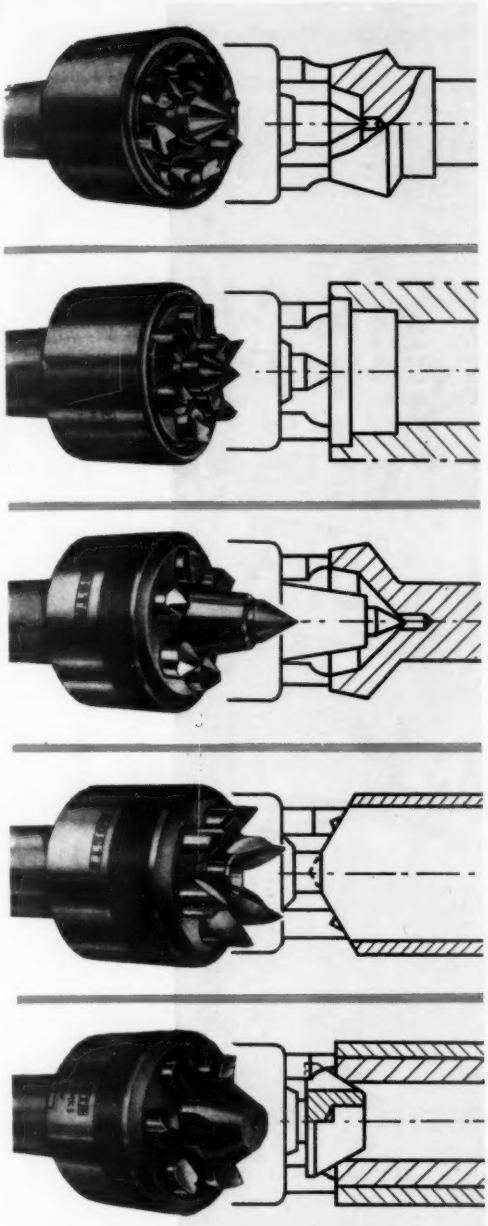

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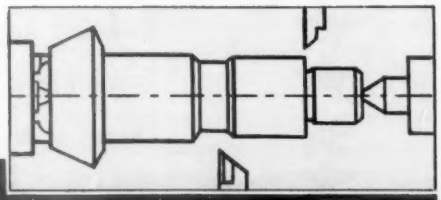

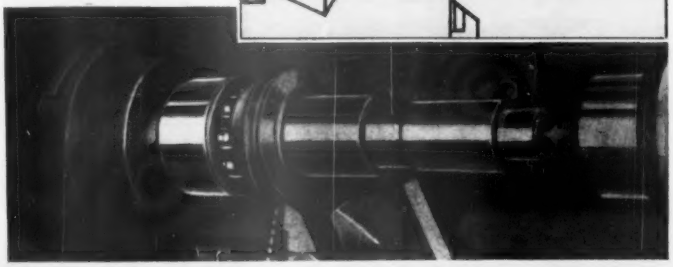

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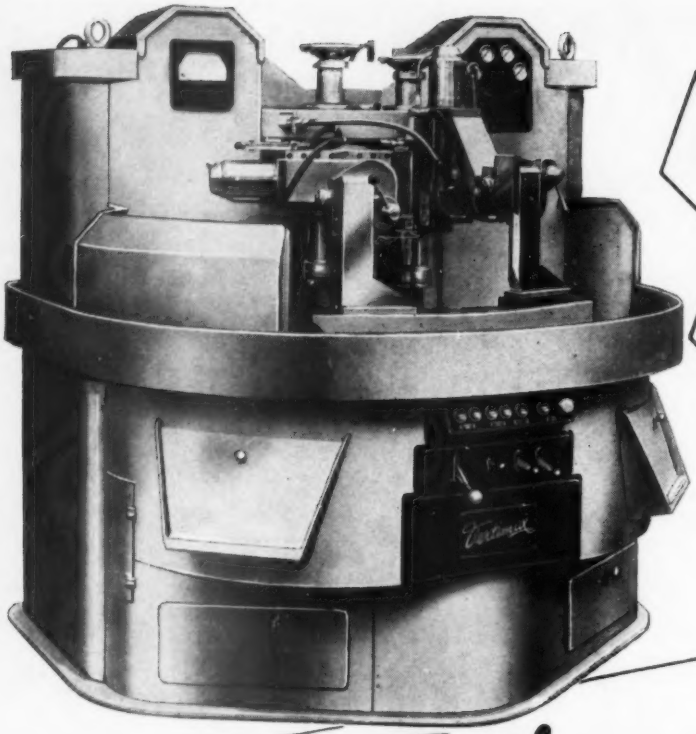

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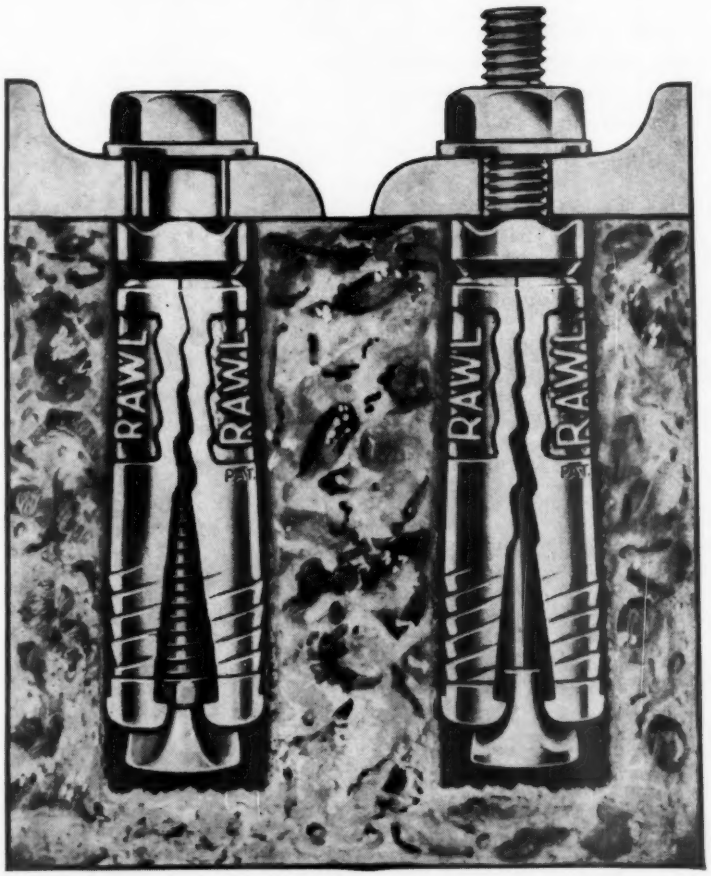

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The Institution of Production Engineers Journal
VOL. 35 NO. 12 DECEMBER, 1956

TEACHING OF PRODUCTION ENGINEERING AT UNIVERSITY LEVEL

Report of a Conference held at The Technical University, Delft, Holland, from 22nd to 26th April, 1956.

In authorising the publication of the report which follows, the Council of the Institution of Production Engineers wishes to make it clear that the report refers specifically to the education of production engineers within universities. The report is not intended to conflict in any way with the proposals concerning higher technological education recently published by the Minister of Education, but is a contribution to the problems as a whole.

The Institution has, of course, pledged its support to the proposals of the Minister of Education and to the proposals of the National Council for Higher Technological Awards.

FOREWORD

THE Conference was initiated by the Institution of Production Engineers. At their meeting on the 8th September, 1955, the Institution's Finance and General Purposes Committee discussed as part of their agenda the following subject :—

Proposed Conference of University Professors

The Chairman informed the Committee that it had been suggested that a two or three-day Conference of University Professors on the teaching of Production Engineering at University level should be held under the aegis of the Institution. It was proposed by Mr. Burke, seconded by Mr. Parsons, and agreed as follows :—

(i) that a Conference should be held in Spring 1956, at Delft, and up to £300 should be paid from Institution funds to cover the costs of the Conference;

(ii) that an ad hoc committee be formed to advise on the arrangements for the Conference, under the Chairmanship of Sir Walter Puckey, together with Mr. Ratcliffe, Chairman of the Education Committee; and Professor Wright Baker, Professor of Mechanical Engineering, College of Technology, Manchester; who would have power to co-opt other members as required.

This was subsequently agreed by the Institution's Council at their meeting on 27th October, 1955, when the Finance and General Purposes Committee's proposal was adopted.

COMMITTEE MEMBERS AND PROCEEDINGS

A committee was set up with the following members:—

Sir Walter Puckey, Immediate Past President (Chairman).

Mr. G. R. Pryor, Chairman of Council.

Mr. R. Ratcliffe, Chairman of Education Committee.

Mr. C. L. Old, Past Chairman of Education Committee.

Dr. T. U. Matthew, United Kingdom member of Inter-University Contact.

Professor H. Wright Baker, Professor of Mechanical Engineering, Manchester University.

Dr. F. Koenigsberger, Senior Lecturer in Production Engineering, Manchester University.

Mr. W. F. S. Woodford, Secretary of the Institution.

Mr. H. W. Badger, Institution Education Officer.

The membership was subsequently extended by the inclusion of:—

Dr. N. A. Dudley, Head of the Department of Engineering Production, Birmingham University.

Professor A. F. Burstall, Professor of Mechanical Engineering, King's College, Durham University.

Professor O. Pope, Professor of Mechanical Engineering, Nottingham University.

Professor O. A. Saunders, Professor of Mechanical Engineering, Imperial College, London University.

Dr. S. Eilon, Lecturer in Production Engineering, Imperial College, London University.

Mr. J. France, Head of Industrial Engineering Department, Loughborough College.

Mr. F. W. Cooper, Vice-Chairman, Education Committee.

COMMITTEE MEETINGS

The first committee meeting was held on 23rd November, 1955, at the Institution Headquarters, the Education Officer having then been requested to act as Secretary and organise the conference arrangements. At this first meeting the venue and approximate date were fixed and it was decided to invite a number of Professors of Production Engineering from leading university centres in countries of Western Europe. At this meeting it was stated that the purpose of the arrangements was to aid industry by utilising the universities to the utmost degree in order to provide better and larger numbers of qualified Production Engineers.

Further meetings were held in February and March 1956 at which the composition of the United Kingdom delegation was determined, the subjects for discussion outlined and the programme of the conference, including the method of compiling a report, decided. Arrangements for accommodation, transport to the Continent, visits in Delft, etc., were left to the Secretary.

CONFERENCE MEMBERS

The members of the Conference who gathered together in Delft were:—

United Kingdom Delegation

Mr. G. R. Pryor, Leader of the Delegation.
Mr. F. W. Cooper.
Mr. J. France.
Professor H. Wright Baker.
Professor A. F. Burstall.
Professor O. A. Saunders.
Dr. N. A. Dudley.
Dr. F. Koenigsberger.
Dr. N. Gross, Imperial College, London University.
Mr. H. W. Badger.

Netherlands Delegation

Professor J. Landberg, Mechanical Engineering Department, Delft University.

Professor R. van Hasselt, Mechanical Engineering Department, Delft University.

Professor T. J. Bezemer, Secretary General, Inter-University Contact, (I.U.C.), Delft.

Professor Verhagen, Technological University, Delft.

Dr. B. J. in den Bosch, Executive Secretary, I.U.C., Delft.

Belgium Delegate

Professor Herpol, Ghent University.

Switzerland Delegate

Professor E. Bickel, Zurich University.

Western Germany Delegate

Professor J. Mathieu, Aachen University.

CONFERENCE ORGANISATION

The United Kingdom delegation assembled at the Grand Hotel, Scheveningen, on the evening of Sunday, 22nd April, 1956, and formed a Steering Committee under the Chairmanship of Mr. G. R. Pryor to decide subjects and procedure during the formal conference sessions. The subjects for discussion arose from recommendations made by British University representatives and adopted during the committee meetings prior to the conference. It was decided to have two main sessions each morning, with a summing up at the last session, so that, broadly, five subjects relative to the conference would be dealt with. A leader was nominated from the United Kingdom delegates to open each discussion. This leader was also made responsible for preparation of a report on the subject he was to open in discussion. Chairmen were appointed for each subject under discussion and also for the topics to be dealt with each evening. The following is the discussion programme prepared by the Steering Committee and followed during the conference.

DISCUSSION SUBJECTS

PROGRAMME

Chairman		*Opener & Reporter*
	Monday	
Mr. France	*Session I.* Establishment of groundwork subjects.	Prof. Wright Baker
Mr. France	*Session II.* Contact between academic and industrial sides, with supervision of practical training.	Dr. Koenigsberger
Mr. Pryor	*Evening.* Views of local industrialists.	
	Tuesday	
Mr. Cooper	*Session III.* Academic studies, Composition of courses in technology and management.	Prof. Burstall
Mr. Cooper	*Session IV.* Level of degree courses.	Prof. Saunders
Dr. Gross	*Evening.* Inter-University Contact for management.	
	Wednesday	
Dr. Koenigsberger	*Session V.* Industrial engineering and its relation to Production Engineering technology.	Dr. Dudley
Mr. Pryor	*Final Session.* Summing up.	Prof. Wright Baker
Prof. Burstall	*Evening.* Automation.	

CONFERENCE MEETINGS

ALL the formal sessions of the conference were held each morning from the 23rd to 25th April in the Conference Chamber of the Old Academy Building, Delft, which was made available through the kindness and hospitality of the Rector and Senate of the Technical University. Each afternoon was spent in visits to laboratories and centres of practical work, where demonstrations and explanations of special procedures and methods pertaining to production engineering were given. Each evening the United Kingdom delegation entertained representatives of prominent local groups concerned with industry, management and education and held informal discussions with them.

Monday, 23rd April, 1956

At 9.30 a.m. the various delegations assembled in the Conference Chamber of the Old Academy

Building at Delft and were welcomed by the Pro-Provost of the Technological University, Dr. C. H. van der Leeuw. Mr. G. R. Pryor, leader of the United Kingdom delegation, responded on behalf of the delegates and of the Institution of Production Engineers which had sponsored the Conference.

The conference then proceeded to formal business which was opened by an introductory exposition of the groundwork at present appertaining to engineering courses in British Universities, with some reference to production engineering with its place and content. The conference was then given the picture of courses of similar standing obtaining in other countries in Western Europe.

From consideration of the broad academic situation the conference went on to enquire into the connexion between academic studies and production engineering practice, and discussed how and when practical training may be acquired, how it should be supervised and what should be the proper contact between the university and industry during a student's practical training.

At the close of the morning session, the delegates were entertained to lunch by the Pro-Provost and members of the Senate of the Delft Technological University.

In the afternoon delegates visited the Delft University Laboratory for Mechanical Engineering Workshop Techniques and Methods Engineering. Professor Landberg, the Head of the Department, gave a detailed account of the course and delegates were conducted round the workshops where students gave demonstrations of normal exercises and special research items in metal working. Various items of methods engineering, including the use of films, were demonstrated.

During the evening a number of Delft industrialists and university members of the Dutch Industry—University Contact Commission had informal talks with conference delegates at the Grand Hotel and explained their work. The Contact Commission is a permanent working body which aims on the one hand at making known what industry needs from the universities and providing industrial assistance by way of practical training facilities, occasional lectures and placings for students; on the other hand the universities make known their research facilities, possible course developments and so on.

Monday, 23rd April, Evening

Later in the evening the draft revision of the examination syllabus then under consideration by the Institution's Education Committee was discussed with the British university representatives. On the basis of the subject headings the university representatives felt that the subjects proposed for Parts I and II were suitable, except perhaps Automation, which was considered rather a collection of subjects, and Metal Plasticity, which was thought somewhat vague. As to Part III subjects, however, the university members considered that at this stage the formal examination procedure of set question papers was inappropriate; candidates at this time are more mature and are usually practising the subject content as part of their daily work. It was therefore considered that the method of testing such ability and knowledge should be that employed in university post-graduate courses, namely, by assessing a written account of a project in industrial administration or allied subjects; a thesis or disquisition on some experiment or research. This, however, should at all times be the result of work and study carried out under supervision similar to that available at a university and there should be a "viva voce" examination of the candidate.

Tuesday, 24th April, 1958

The formal conference session commenced at 9.30 a.m., with further discussion on the academic studies in production engineering appropriate in universities, with particular attention to courses in management studies and specialist technologies. The Conference proceeded to tackle this fundamentally and discussed the original growth and development of industry, starting from the history of engineering and materials and leading on to the relationship between men and machines, refinements of metallurgical processes and the application of statistics. A contrast was drawn between the evolutionary ways of Western Europe and the rapid expansions taking place in the Soviet Union where the rate of progress has already produced Professorial Chairs in such subjects as Jig and Tool Design; subjects for university study in Russia contain items such as "The application of energy to human purposes".

The conference then went on to discuss the level of degree courses in production engineering—whether they should be first degree or post-graduate. Again, the approach was from fundamental aspects. It was stated that the universities endeavour to train a well-selected element of the population in the disciplines of pure thought plus the use of imagination; the essential subjects utilised for this purpose in the case of future production engineers are the physical sciences, economics and psychology.

In the afternoon the delegates visited the Delft University laboratory of Control Processes, where a preliminary talk was given by Professor Boon. Demonstrations were given of the regulatory techniques practised and the compilation of statistical information with its control application. The delegates then visited the Management Foundation Building, which co-operates with the University. There Professor Bezemer gave an outline of the training and research courses in management which are provided for students from all parts of the world; many come from Asiatic countries. Examples of case studies were shown, both undertaken while on course at the Foundation and also as instances of practical assistance in management and organisation when students have returned to their own countries and have taken up executive posts.

In the early evening the delegates were entertained by the Inter-University Contact (I.U.C.) Organisation. This is a body through which University Professors of Management studies at main leading university centres in Western Europe exchange

ideas, hold conferences and generally promote and assist the furtherance of management studies at higher levels. Discussion on management problems continued with the Netherlands members of the I.U.C. later in the evening.

Wednesday, 25th April, 1956

The conference assembled at 9.30 a.m. and devoted the first half of the morning to industrial engineering, its points of difference from and its relationship to production engineering, and the way in which industrial engineering may be associated with technological subjects.

The latter part of the morning was reserved for a preliminary summing up of the general debate. The pattern of the summing up showed that four main threads had predominated during the discussions. These were:—

(i) university training in general, with the meaning and extent of production engineering studies in particular;

(ii) the kind of practical training required and its relationship to the university course;

(iii) the particular production engineering subjects appropriate to university courses and the composition of such courses;

(iv) post-graduate courses following a first degree in basic engineering.

On this pattern of the summing up it was subsequently decided to base the main sections of the report.

The formal sessions of the conference were then closed by the leader of the United Kingdom delegation, Mr. G. R. Pryor, who thanked all those who had come from several universities in Europe to assist in the debate and also the University of Delft for its generous hospitality.

In the afternoon the delegates went first to visit the Delft University Laboratory of Technical Physics where research is conducted into advanced forms of instrumentation. Professor Verhagen, the Head of Department, gave a preliminary talk on the department's contribution to automation. Afterwards delegates were given demonstrations of servo-mechanisms, the logic machine (a method of data selection), mechanical and electrical behaviour devices and so on.

Later in the afternoon the delegates divided into two parties, one of which went to the Royal Dutch Shell Laboratory to be shown the application of hydraulics and pneumatics for servo-mechanism, control systems, measuring devices and so on. This is of particular value for the application of automatic methods and control processes in the remote areas of the world where electricity is not easily available. The other party went to the Laboratory of the Dutch Government Industrial Consultation service, to be given examples of automation.

During the evening there were discussions on automation problems with Professor Verhagen and Dr. Hyams of the Industrial Consultation laboratory. Dr. Hyams gave the delegates an extensive picture of the developments of automation from essentially simple beginnings and he added illustrations on the psychological problems of the subject.

The Conference was now concluded and on Thursday, 26th April, the delegates dispersed.

REPORT ON THE TEACHING OF PRODUCTION ENGINEERING AT UNIVERSITY LEVEL

UP to the present time, production engineering education and practice have largely been fostered by the Institution of Production Engineers, who have worked hand in hand with the Technical Colleges throughout Great Britain to meet this urgent need of industry. To the impetus of the Colleges is owed the great strides that have taken place since the War, not only in the advance in production technology but also in the expansion into the fields of management practice. In the fires of their experience the Technical Colleges forged the framework of curricula necessary for the academic training of a production engineer and the Institution joined them by setting the pattern of its examination standards and subjects in line with that of the Colleges. To this fruitful partnership the Ministry of Education gave its help through the National Certificate and Diploma schemes.

The general pattern of education and training necessary to provide production engineers stands at present as follows:—

(a) A good general education, preferably acquired while at school. This should have three main branches, all at G.C.E. ordinary or similar level:—

  (i) English—the ability to comprehend and to express in simple, clear and precise terms.

  (ii) Mathematics—the fundamentals necessary for whatever technological studies are later pursued.

  (iii) Science—Physics: Heat, Light, Sound, Principles of Electricity and Mechanics. Chemistry where necessary for later technological study.

(b) A special Technology, always including the appropriate—

  (i) Processes and practices of design for production.

  (ii) Manufacturing processes and practices.

(iii) Advanced technological study.

(c) Applied Management Practice including—

(i) Industrial Organisation.

(ii) Rationalisation of methods.

(iii) Sociology.

(iv) Production Economics.

Students attending universities in the United Kingdom to study engineering satisfy the first requirement. But hitherto, in many cases, the university path has led away from the production side into the realms of advanced disciplinary training in mathematics, science and technology, with emphasis at later stages on pure design and research. It has been felt that knowledge of manufacturing methods and ability in management would come with experience some time after students left the university.

It is against this background that the Institution arranged the Conference at Delft and invited British university professors to see how far their university courses could be matched with the present trends of production engineering education as seen by the Institution, and as already practised in universities on the Continent.

A Long and Complex Process

The training of an engineer to take his full and proper place in industry and in the service of his country is a long and complex process, which should be kept constantly under review and modified from time to time to suit changing circumstances. These modifications may be relatively simple, such as additions made to a teaching syllabus to cover new theories and techniques, or more sweeping, such as when some section of the work becomes sufficiently important or complex to justify separate consideration. The complete training must of necessity include a knowledge of men, materials and machines and an appreciation—adequate to the work to be undertaken by the individual—of value and costs, of legal and social responsibilities, and of many other factors.

It is well that changes in well-established practice should not be made "without adequate consideration". But it is now clear that this country has been extremely conservative and, by failing to make the necessary changes as rapidly as some other lands, is in danger of being left to meet new competition with old practices amid widely changed circumstances.

A striking example of the increasing rate of change in engineering can be found in the development of prime movers. The great days of the reciprocating steam engine lasted for about 150 years; developments took place in what would seem relatively small steps based on gradually increasing understanding and the slow refinement of processes and practices. In the development of the petrol engine the same stages, under the stress of great popular interest and national need, were largely covered in one third of that time; scientific study of the complex phenomena encountered rushed forward to try to keep pace with extremely ingenious experimental developments.

With the gas turbine development has taken about a third of the time of its immediate predecessor, and scientific knowledge has led in both the design and the manufacturing processes. Though these examples are taken from the conventional field of mechanical engineering, it is obvious that corresponding developments have taken place in each section of the production processes owing to new methods of manufacture, handling, control and so on.

It would be wrong to belittle the great achievements of engineers of the past, or to cast a slight on the long and often excellently directed apprenticeship which produced the master craftsmen, or on the great reliability of the work of past designers. But we are in a modern world, with new knowledge, new materials, new processes, and demands and urgencies undreamt of a few years ago—the days of sintered metals and plastics, of minute tolerances on millions of articles, of the automatic machine and the automatic factory, when labour is no longer at the whim of a buyer's market, and when half a world has awakened from an ancient slumber to a modern vision. Specialisation within the team has come since it is no longer possible for one man to acquire sufficient knowledge and ability to handle all the problems to be faced, even were there time available to try. Education, whether in the workshop or in the study, must recognise the changed circumstances and make the necessary adjustments. Nor is it enough to consider present needs only. The man who begins his professional training to-day may well not be carrying a man's load until six years ahead or feel the full weight of his responsibility for yet another ten.

It is because in Britain the urgent need was felt for an immediate review of the complete field of training for professional production engineers that this Conference was arranged, and it is desired to express the greatest appreciation of the offer made by Continental colleagues for the help given in considering the task.

It seemed desirable to limit discussion to one particular level, choosing that of the university on the ground that, while the divergencies between British and Continental practice are marked and considerable alterations may be desirable at home, the elasticity of the British University system and the relative consistency of that small proportion of the population making up its student body are factors which make experimentation and development relatively easy and rapid. The needs of industry cover a very much wider field which may require consideration in due course, but the restricted field selected seems to be the best starting point and the one which is most likely to give early results and set a pattern which may influence others.

The Purpose of a University

The purpose of a university is the development of a student's ability to think logically, critically and constructively in relation to his chosen field of study; to acquire social interests and an appreciation of the broader fields of facts and theories which may help him in later life; not the least of these is that of individual and group behaviour. The staff of a university should be composed of those who are still themselves learning while at the same time being specialists in their particular subjects. There is no

doubting the importance and value of the very close contacts between students and staff but there is also risk that, while the discipline of study may be excellent, the range of the students' own interests may remain—or become—too narrowly "academic" and not well suited to those who at a later stage may enter the production side of engineering rather than that of development of design or research.

In Britain it is customary for the academic education of university students to consist up to the age of 21 of two sections; the first taken in the schools up to the age of 18 leading generally to the G.C.E., with advanced Mathematics, Physics and some Chemistry; the second consisting of three years of professional study leading to the degree of Bachelor.

During the three years leading to a first degree, about 2½ years must be given to fundamental subjects, leaving little time for the students' more special interests.

Human Problems

Furthermore, owing to the immaturity of undergraduates it is not desirable to devote much of their time to the study of human problems, with which they will have had little contact. These may well be considered at post-graduate level, either separately or in conjunction with some other "special" subjects related to production.

It is, however, becoming increasingly possible for a student to give more attention to his "special" subject, including the study of human problems, in a post-graduate course of instruction (as contrasted with post-graduate research), and certain of these courses may well be taken separately from the first degree course or as refresher courses after a period in industry. Training in "Research" given at universities is not considered here.

The industrial side of early training follows one of two patterns. The old tradition was for the student to serve an apprenticeship, not differing greatly from that of the normal craft apprentice, with a complete break for a considerable period between the "academic" and "applied" sections. There was little appreciation that a man in a high-intelligence group could learn quickly under proper conditions and that, in fact, he had potentialities for special usefulness in relation to the more scientific side of industry which should not be given too long to "cool off".

One matter, now frequently stressed, is the development of and understanding of the human aspects of industry with which the student has probably had little contact. But the development of the student's knowledge of human problems was often seriously hindered by failure of his industrial colleagues to understand him. There have been vast improvements in this respect in recent years but there is still a good deal of prejudice—on both sides—to be removed.

Nowadays works training has largely been dropped from university courses, in the first year of which it used to play a prominent part. It is usually taken after the university studies, though workshop practice during the vacations is expected or required.

A few of the very large firms have their own schools supplying special graduate apprentice training on both the workshop and the technological sides, under the guidance of highly qualified staff, and sometimes in close collaboration with a university department. Such schools are still flexible in structure and further developments may be anticipated. There are at present no corresponding schemes for university students among the medium and smaller firms, but group schemes operated by numbers of smaller firms are now commencing for ordinary apprenticeships.

In addition to under-graduate courses, post-graduate courses of instruction (not to be confused with post-graduate courses of Research) are becoming of increasing importance. Among these are post-graduate courses in Production Engineering and in Industrial Administration. Such courses may have special importance in the study of human problems, as students at post-graduate level—especially after a period in industry—are sufficiently mature to develop a realistic approach to this subject.

In general, therefore, it can be said that in Britain at present the post-school training of the university educated production engineer is provided by adding together, without integration,

(i) a standard under-graduate course built on basic engineering and the customary selected subjects;

(ii) some vacation workshop experience, and

(iii) post-graduate training in industry,

(the order may be varied somewhat). There is considerable need for an extension of training in selected subjects relating to production engineering, both in the technical and the administrative fields, and for a systematic introduction to the simultaneous application of both scientific and industrial methods of attack on industrial problems.

The degree of Bachelor is awarded on satisfactory completion of a first course at a university. Full professional recognition is accorded by the appropriate professional institutions only when the whole training has been completed.

Continental Training

The Continental practice, though showing considerable local variation, as is also the case in Britain, follows a different plan. There is a basic training in mechanical engineering very similar during the first three years to that provided in Britain, but the work of students in industry during the vacations is under close supervision. There is no award corresponding to the Bachelor degree. The training is continued under university supervision for a further period of at least 18 months, during which the whole workshop experience in industry is brought to a total of about 12 months. Further courses of instruction are given in special branches of study, of which there may be certain options, and "projects" are studied for periods of about 8 weeks each, each problem being tackled either in the university or in industry according to its nature and under a form of joint university and industrial supervision.

The work of instruction is divided between the

full-time members of the university staff and part-time Associate Professors, who are appointed for their specialist knowledge and are not held responsible for general university policies and routine administration. The full-time members of staff have access to their students during the project study in industry.

The professional award of Diploma Engineer (Diplom.-Ingenieur) is given at the end of the full course of training, involving the systematic integration of academic and industrial components.

The total academic content is considerably more than in the course for the British Bachelor degree. Careful and realistic planning of the introduction to industry should mean a reduction in the time required for a student to "find his place", and it should be possible to attain the high and exacting professional standard required at the present day with greater certainty and considerably more efficiency than are achieved by the present normal British practice, in which the teaching partners—the universities and industry—tend to stand apart.

The above review is of a very general nature only. Divergencies in practice are quite marked and individual procedures are by no means static. The relationships between industry and the universities vary very widely and are considerably affected by the traditions, the nature and the size of the dominant regional pattern of industry.

A closer study of the Continental picture may very well be of great benefit to those reviewing current British practice. It was with this in mind that the conference was conducted in sessions, each dealing with specific problems. These have been summarised in the following sections leading finally to the specific recommendations made to the Institution of Production Engineers by the British representatives at the Conference.

SECTION I

The meaning and extent of production engineering training as considered by the Conference

"Production" involves the management of processes, machines and men, and the training includes basic sciences, the requisite technical subjects and their industrial applications, and the basic principles of management.

There is no doubt a considerable body of knowledge common to all forms of production, but the acquisition of the knowledge of a particular technology must of necessity dominate any particular course, and will occupy such a large portion of the time available that it is essential to restrict courses to limited fields. For instance, it would be impractical to expect a student to attain the necessary standard of technical knowledge in both the metal working and the foodstuffs industries.

The production of articles in metal is of all the fields of production much the most complex, universal, varied and deeply involved in human problems. It is also the one which has received most attention in relation to matters of education. It is, therefore, appropriate that, in the university, metal working production should continue to be the main field of investigation and experiment for the present.

At post-graduate level it may well be practicable to devote a larger portion of the total time to subjects related to general economic, legal and managerial factors, but to divorce such a course from a specific technology would tend to divorce it from the hard core of reality. Separate courses related to production technology other than metal working might well become profitable when the present experimental work has made adequate progress and some measure of interlocking of such technological courses may prove feasible.

It has been shown that men trained in basic engineering production can find useful employment in, say, the textile, chemical or foodstuffs industries once they have become acquainted with the necessary technical facts. The range of processes and products is often much more restricted in these industries than in metal working and may even be confined to the production of a single standard product.

Engineering aspects of metal production will continue to cover a very wide field even should automatic machines greatly reduce or alter the human and sociological problems. Fully automatic production will continue to have very much in common with more conventional methods and the mechanical and electrical data are very similar to those for conventional processes.

The principles of work study, works organisation, plant layout and so on, may be common to a wide field of production but they should be studied in relation to processes known to the student. Metal working engineering production seems to offer much the best range of case studies and may well prove to be the most fruitful field for experiment for the present. "Work Study" is certainly an essential factor in a production course and offers considerable scope for continuing research but it is only one of many. Though limited management studies have a proper place in a production course for young men, they should be confined to the final stage of the course when the men are reaching a measure of maturity and care should be taken not to crowd in too much at the expense of training in the basic technological disciplines.

Only a very small portion of any normal group will prove to be fitted for high managerial positions; special aptitudes and desires must be developed and proved before attempting an appreciable measure of specialisation and the major part of a class of immature men—probably as much as 97%—may well be seriously harmed by being given the impression that they have the knowledge required for management and have conquered the tricks of human psychology while they do not understand life.

Those who have the ability to rise to be top managers and leaders must be considered as among the very few who are born to occupy highly individual positions. They cannot be made. If the tools are given to the right man he will make himself a leader. It would be quite unrealistic to attempt at an early stage to provide a course in the hope that a certain proportion of the students would become "top managers". If the courses are elastic the future "top

manager" type of individual will receive proper instruction and will not be hindered in his development, while the bulk of the students will be well and efficiently trained.

SECTION II

The Co-ordination of Industrial Work and University Study as practised on the Continent

It is generally agreed that, in the study of engineering in general, and of production engineering in particular, the practical aspects are of special importance because production really means the translation of ideas into practical application in the workshop. The teaching of production engineering cannot divorce itself from this fact, and academic study of the subject must, therefore, keep in close touch with production engineering practice. This connection has to be twofold:—

(a) Sound experience of the practical processes used in the production workshops. This is a necessary foundation of the engineer's work.

(b) Active contact with industrial problems. This is essential for the full appreciation of the methods of developing and applying practical solutions.

In this connection it must be remembered that the aim of university training is the teaching of a logical method of approach and the development of those powers of critical observation and constructive thought essential for the making of decisions relating to methods and procedures. This form of training is proper to the intellectual discipline of a university.

University training should be responsible for both the foregoing items (a) and (b) in the following manner:—

In his practical training in the workshop the student must be made to *see*, *handle* and *observe* in order to visualise the possibility and the basic principles, to get a certain humility in appreciating the difficulties which a craftsman has to overcome and to analyse systematically the problems involved. It should not mean that he has to "serve his time" as a craftsman-apprentice, nor does it mean that he should only go round and watch the processes and procedures in operation.

This practical training must be carefully organised. The student must not be left to decide when and how to obtain it, and a continuous check must be made in order to ensure that he is offered what is needed, that he knows how to gather it and—at the end—that he has absorbed it and learned what is expected and required.

The questions which the members of the Delft Conference were asked to discuss or to answer were the following:—

In relation to (a)—

1. What is the best time for university students to carry out their practical work in industry (at the beginning, at the end or during the course)?
2. Should the university actively collaborate with industry in the planning and guiding of the work of the students during their practical training in order to ensure that they carry it out satisfactorily and effectively?
3. Is it considered necessary to test whether or not the students have derived any benefit from their practical work, and if so, how is this done?

In relation to (b)—

Practical contact with actual production problems of an advanced nature may be obtained by tackling these problems on a relatively small scale, in the form of project studies reported in theses presented in part satisfaction of the requirements for the university award.

In this connection the following questions were put to the members of the Conference:—

1. What are the typical subjects of project studies given by Continental universities to the students?
2. How is the work organised, bearing in mind the limitation of time which is unavoidable?
3. How do universities' supervisors stand in regard to industry when students work on projects of actual industrial significance and importance?

The following points emerged from the discussion with the various Continental members of the Conference with regard to the two subjects (a), questions 1, 2 and 3 and (b), questions 1, 2 and 3.

(a) 1. There was general agreement with the fact that for a university student a sandwich course (six months at the university and six months in the workshops) is entirely out of the question because university work, particularly its essential researches, cannot be carried on if interrupted at six-monthly intervals. As for the timing of practical workshop training, there are good reasons for taking it before the beginning of the university studies as well as reasons for taking it at a later date. It has been found that students who have worked in shops before entering the university show much better understanding of the problems put to them in university lectures. On the other hand, students who have already gone through a certain university training appreciate to a much greater extent what they see and learn during their practical work in the shops.

With the exception of France and Belgium, it appears to be the general practice to make a certain period of practical workshop training compulsory before admission to the final examination. In Germany and Switzerland, the period in question is usually one year, of which six months have to be taken prior to the commencement of university studies and the remainder during the vacations.

In Delft the students get some elementary workshop training in the university workshop laboratory (one afternoon per week for about fifteen weeks), and later, during their vacations, are placed in industry for periods of not less than six weeks which have eventually to add up to half a year.

The German and Swiss point of view is strongly opposed to the installation of a training workshop in the university, because of the lack of factory atmosphere which is considered most essential from the point of view of forming the student's character and his appreciation of factory and workshop life.

(a) 2 and 3. Most universities arrange for the practical work to be supervised. At Delft a special member of the staff is in charge of this under the supervision of a Committee of the Faculty. The students have to produce reports of their work certified by the works management, and these reports are discussed between the students and the member of the staff in charge of practical work. This engineer is also expected to visit workshops all over the country in order to make certain that the work is of the necessary standard and that the students get the opportunity to see everything required.

Switzerland is following a practice on the lines developed in Germany about thirty years ago which is based on the following principles:—

Each Technical University has an "Office for Practical Workshop Training" (Praktikantenamt). This Office has to approve the companies in whose works the students are authorised to carry out their practical work, and only the work in workshops approved by the universities is recognised when the student registers for his final examination. At the end of certain periods, the student has to submit a log book describing the work he has done and showing by means of sketches, diagrams and his observations that he has fully appreciated what he has learned.

The contents of the log book are discussed with one of the members of the staff of the Office for Practical Workshop Training and each period of work has to be approved by the university before it can be recognised as part of the minimum required for registration for the examination. This minimum is twelve months, six months of which are taken at the beginning of the university studies and the remainder during the long vacations.

The Swiss Office for Practical Workshop Training has an agreement with the Society of Swiss Manufacturers in which the management of the various companies agree to take good care of the students' training and, as far as possible, keep it in accordance with rules given by the Zurich Technische Hochschule. A member of the university staff acts as secretary of the Office and supervises the practical training. He has to watch the efficiency of the training and comment on it both to industry and to the university. He also visits the various factories and is authorised to discuss with the students and with the management any grievances which might arise.

(b) 1. The subjects given by Continental universities to their students for project studies vary according to the standard required. Several study exercises have to be carried out during term, such as designs of typical machine elements and reports on laboratory experiments. During the final two years, out of a minimum of four years devoted to professional studies, however, two to four so-called "study projects" of a limited magnitude form part of the requirements for admission to the final examination; the estimated time to be spent on each such project in the university is six hours per week. One of the study projects is concerned with design. The others, normally two per year, may deal with such matters as plant layout, pure theory or investigation. Part of the final examination for the first award consists of a "Diplom-Arbeit", a thesis based on a larger project in the same fields as those of the first award or of research more original in character and reported in the form of a thesis.

The time allowed for the "Diplom-Arbeit" is usually limited to three months but may be extended if considered necessary to six months.

Design problems are relatively easy to set (usually they take the form of a design to a specification supplied by the Professor). In the field of industrial work, industry is frequently asked for typical problems which require investigation and which may be suitable for the purpose. Sometimes industry may submit problems to the universities who, in turn, may send some of their students to the factories in question in order to carry out investigations on the spot, under the supervision of both the works engineers and—of course—of the professor in charge.

In many instances it is naturally difficult to reconcile academic requirements with the purely practical problems found in the workshop and with the industrial need for speed of work and expedition in finding workable—even if not scientifically sound—solutions. It is here, of course, that the professor's teaching ability, intellectual way of thinking and engineering experience, have to come into operation in order to sort out and reconcile the various contradictory requirements. Problems and solutions satisfactory to both sides have usually been found in most cases. At Delft many students specialising in Production Engineering have been placed as salaried assistant engineers in different works with which the University has regular contact, and where they work on problems of direct practical importance to the firms concerned. Frequently, a student who has carried out such investigations, is appointed to the staff of a company in question after he has obtained his university award, in many cases with the object of continuing the good work started when working for the award.

(b) 2. Both in teaching and supervising study projects, Continental universities bear the practical industrial aspect well in mind. Aachen has just appointed a Chief Engineer in charge of Design at the Chair for machine tools, who had previously been Chief Designer of one of the leading machine tool makers in Germany and who is allowed to work as a design consultant to machine tool manufacturers during his term of office at the University. Similarly, the Extra-Ordinary Professor of Machine Tool Design at Delft is also Chief Designer of a Dutch machine tool firm. At Zurich it is considered not only possible but preferable that the basic principles of engineering design, the scientific and systematically laid foundations, should be taught in lectures given by a member of the university staff. However, the application of these principles, the actual approach to design problems and the execution of the design with all the considerations of detail which may determine success or failure, technically or economically, are

taught by a designer from industry,specially appointed for the purpose. For one or two afternoons per week, this man supervises the design practice of the students who have been given their task in the form of a design specification, the whole amounting to the teaching of the subject in the form of case studies.

It is up to the Professor who sets the problem and who supervises the work to see that a reasonable result can be produced in the limited time available and that this time is spent on the essential points of the problem.

(b) 3. The relationship of professors to industrial organisations enables suitable projects in industry to be selected for students under their supervision. Sometimes the professors are active members of firms of consulting engineers and as such are able to apply in industry many new ideas which are often based on academic studies and developments.

At Delft the "Foundation for Training Courses and Research", founded with the full co-operation of the Technical University, organises courses of Production Engineering and Industrial Administration both for students and for industrialists. University students may be seconded to the Foundation in the same manner in which they would be placed in industry. Two Professors of Delft Technical University, one of whom is also the head of a large firm of industrial consultants, are on the board of the before-mentioned "Foundation" and form the practical link between it work and that of the University.

SECTION III

Production Engineering Studies and the Composition of Courses

In the discussions relative to this section it was endeavoured to determine—

(a) the studies peculiar to production engineering which will provide the essential academic discipline and

(b) the composition of appropriate courses.

In most British Universities, too much emphasis is placed on higher mathematics in the selective teaching of students interested in production engineering and, as university courses are traditionally based on higher theory and research, the problem of recruiting men to university staffs who are well versed in production engineering at the appropriate level is serious. As more courses with a production engineering bias are introduced this difficulty will presumably decrease, but obviously a succession of courses cannot be operated if they are entirely dependent on individual teachers who cannot be replaced.

The university syllabus should include subjects taught in stages progressively increasing in difficulty and reaching the requisite standard as intellectual disciplines. They should, moreover, introduce the creative, as well as the analytical, in approach.

"Design for production", if treated in a creative manner, can provide such a subject, and the part-time help of industrial designers in the latter stages of the course may prove beneficial.

The method of teaching in the Machine Tool and Metrology laboratories by the method of "direct observation", in contrast to the conventional one of "individual use", has proved beneficial in providing a satisfactory course of a standard appropriate to the third year of training.

Courses considered suitable include lectures on Engineering Production Processes, an introduction to Industrial Health, Advanced Metallurgy and Applied Statistics. Other subjects which might be appropriate include "Applications of Energy to Production Processes" and the development of "Mechanical Movements". There could be a reduction in the conventional content of Thermodynamics, Strength of Materials, Graphical Calculations and Higher Mathematics, but Industrial Metallurgy and Electronics should receive adequate attention.

The following points appear to have support:—

(i) That the course for production engineers may well be combined with that of the mechanical engineers for the first two years of professional study. At the end of that time the student, according to his inclinations and abilities, can be advised on his future course.

(ii) That the average time which a student may expect to devote to his studies per week is in the order of 50 hours.

(iii) That Mathematics should be considered by engineers primarily as a tool and its study need not be extended much beyond the second professional year. Mathematical statistics may well take the place of Mathematics in the third year for students studying Production Engineering.

(iv) That the teaching of Engineering Design can be based on the consideration of small units selected to emphasise specific points. Design as a whole combines a multitude of factors involving both science and art, the functions, materials, processes of manufacture and the factors of costs, and students should not be faced with design problems which are in reality far too complex for them to comprehend. Some problems may illustrate the selection of materials, some the problems of applied mechanics others that of the rigidity and so on. The design of jigs and fixtures is especially to be commended as it introduces many problems, each device being different from the rest.

The teaching of Design is helped by frequent contact between students who are working on a group project, and between the individual students and their instructors, so that mistakes and alternative plans can be discussed at any time. This makes a very heavy claim on the staff and industry can help greatly by the loan of designers on a part-time basis. The larger projects in the final year, say the design or layout of machine tools, may have to be under the care of a Professor Extra-Ordinary who is himself an expert on the subject. Effective collaboration with industry with regard to both teachers and teaching materials is essential.

SECTION IV

Post-graduate Courses

This section is concerned primarily with the suitability of one-year courses of the post-graduate type following a basic course of Engineering, either immediately or after the university student has spent a period in industry.

The provision of certain production options in the third year of a Mechanical Engineering course provides for a blending of the sections which has many attractions, but may not be practicable in certain universities or districts. The provision of specialised post-graduate courses in certain localities in order that the whole may be covered may therefore be desirable; this is the concept on which the Regional Scheme of Further Education is based.

In the introduction to this subject a clear distinction was made between the nature of the first period, i.e. the three years of professional studies in Britain generally leading to a Bachelor's Degree, and subsequent courses of study not associated fundamentally with "Research".

The first period should provide a broad general training in basic principles, a considerable proportion of which is common to several branches of engineering and, though the interests of students may well be stimulated in the special fields they wish to enter subsequently, the intense study of these fields must follow the basic training. This specialised study and training is considered, in Britain, as post-graduate in level.

Can adequate courses for the training of Production Engineers extend into this post-graduate region, and can they be separated into undergraduate courses in basic engineering followed by post-graduate courses in the specialities of Production Engineering? One post-graduate course in Britain, generally intended to be one year's duration, is based on Engineering ranging from production technology to production management, and includes economics, law, industrial relations or physical science, economic sciences and psychology.

The problem of the selection of teaching staff must, in this post-graduate field, be mentioned again and the importance of the help of first-class specialists from industry on a part-time basis is stressed. Production engineering touches many basic sciences and the success of a course depends on the correct and harmonious blending of the components under the wise guidance of a professor and the help of part-time specialists may prove extremely valuable. The contributions of all these specialists, each sometimes having his own section, staff and research workers, must be gathered and blended in courses for Production Engineering training.

On the Continent the separate sub-divisions of the special Production Engineering curriculum may involve professors of Machine Tools (or Technology), Industrial Psychology, Physiology, Organisation and Accounting, all embraced in the department of Mechanical Engineering.

A second post-graduate one-year course normally taken by students in their late twenties (25-28 years) exists in which one-third of the time is devoted to lectures, one-third to group case-studies in industry, and one-third to industrial projects based on industrial problems. In the course active contact is maintained with a residential college running special refresher courses for senior production engineers and industrial managers. This connection is of special value to the staff conducting the full year course.

In conclusion, it may be inferred that the student trained by means of an integrated scheme such as is described in the foregoing sections cannot claim to be equally effective over the whole field of Production Engineering, but he will have a sound foundation in basic science, a good appreciation of the technologies both in theory and application, and should be well acquainted with whichever branch of the subject he has selected for his special field, whether it be of design, or of planned production, or of administration and management. The inclusion of considerable periods of industrial experience, both at workshop level and by the contacts established through his specialist teachers and his project investigations, should fit him to receive professional recognition as a Production Engineer capable of playing a distinctive part in the industry of his country.

RECOMMENDATIONS

As a result of the Conference, the members of the United Kingdom delegation recommend as follows:—

(i) that there be further development of university schemes in Britain which will provide integrated courses involving—

  (a) not less than 12 months guided and approved workshop practice;

  (b) approximately 3 years' basic engineering study at university level, if possible with some bias towards the principles of Production Engineering in the latter stages, and followed by

  (c) one full year or more devoted to the special subjects of Production Engineering, including "projects" on matters of industrial interest selected as far as practicable to meet the needs and interest of the individual student;

(ii) that industry be urged to give all the assistance it can to further the development of such schemes and, in particular, to see that the industrial aspect is adequately supported by the collaboration of specialists whom industry alone can supply. In this, industry will be helping in the preparation of the most scarce of the "materials" which it needs;

(iii) that full professional recognition be given on the successful completion of such an approved university course taken as a whole or as an acceptable combination of undergraduate, post-graduate and industrial components.

PRECISION CASTING BY THE 'LOST WAX' PROCESS

by R. G. NICHOLAS.

Presented to the Manchester Graduate Section of the Institution, 9th November, 1955

Mr. Nicholas was born in Newbridge, Monmouthshire, and studied engineering at the Monmouthshire Mining and Technical College. After serving for four years as a commissioned observer in the Fleet Air Arm, he continued his studies at Miles Aeronautical Technical School.

In 1949, *he joined the Metropolitan-Vickers Electrical Company as a College Apprentice, and is still with this Company. After completing his apprenticeship, he was appointed Development Engineer in the Precision Casting Shop and later Engineer-in-Charge of this Department. For the past two years he has been employed as a Manufacturing Engineer in the Process and Rate Department, being primarily engaged with tool and gauge manufacture.*

Mr. Nicholas

THE "Lost Wax" process of casting has been known to man for at least 4,000 years, having been practised by the ancient Egyptians and later the Chinese in the Chang Dynasty for the making of jewellery and objects of art. The process has been rediscovered on various occasions down through the centuries and employed for this purpose.

During this century the process has been used by the dental profession for the purpose of fitting gold caps on to the stubs of broken teeth. This is done by pressing a piece of wax on to the stub, carving while still in position to continue the lines of the broken tooth, and then removing and using this destructible pattern to cast an accurately fitting gold cap.

It was not until 1942, however, that the process was introduced into industry as a production consideration in the U.S.A. The advent of the gas turbine and the difficulties of producing large numbers of complex blade forms in materials difficult to machine, caused the engineer to look around for other methods. So it was that the process was once again "discovered".

Although the materials used for the process have changed and the needs of mass production have necessitated tooling up, the basic principles of the process have remained unchanged down through the centuries.

Principles of Process

The principles of the process, which are shown in Fig. 1, can be considered as comprising three basic steps: the manufacture of a destructible pattern, the formation of a one-part refractory mould around this pattern, and the subsequent removal of the pattern; and the casting of metal into the mould cavity so formed.

The first step, however, is to design, or, as is more generally the case, to redesign the component as a

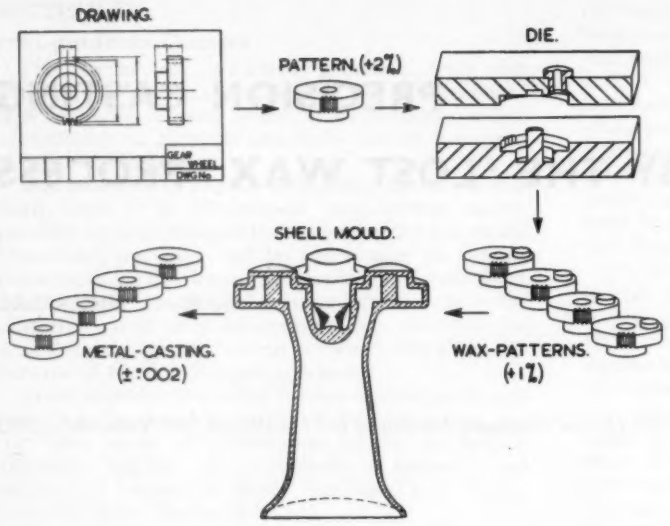


Fig. 1. Principles of process.

cast product. This step cannot be over-emphasised. Sudden changes in section and other causes of casting failure could often be avoided by consultation with the foundry engineer during the early stages of design.

Destructible Pattern

The pattern material must be of such a nature that it can be removed completely from a one-part casting mould without damage to the mould. Essentially, this means that the material must be capable of being melted, burnt or dissolved from the mould, leaving a minimum amount of residue. It should have a low co-efficient of expansion and contraction, (otherwise there is a danger that the mould will be damaged due to temperature variations during manufacture), and should also be resistant to attack by the mould materials. Finally, to meet the needs of industry, it must be of such a nature as to enable large numbers of identical patterns to be produced economically—this is generally achieved by injecting the pattern material into a die.

A variety of waxes, polystyrene (a thermosetting plastic) and even mercury have all been successfully employed as pattern materials. Wax is the most versatile of these materials and is employed by the majority of manufacturers in this country. It can be injected in the liquid state at comparatively low temperatures and pressures, and so permits the use of soft metal and plaster dies. Polystyrene, on the other hand, necessitates the use of both high temperatures and pressures and, consequently, the injection plant becomes more complex and water or air-cooled steel dies have to be used. This material is widely used in the U.S.A., where it is claimed that for production runs of 5,000 off or more it is more economical than wax; the lower cost of polystyrene more than offsetting the increased cost of tooling. Mercury patterns are formed by pouring liquid mercury into a die and then reducing the temperature below its freezing point. It is claimed that much thinner and more clearly defined patterns can be produced by this process. Further, the pattern can be removed from the mould without the danger of the mould cracking. However, the fact that the process has to be operated at a temperature below —38°C. during mould manufacture presents many problems and consequently mercury is not a widely used pattern material.

Dies

(Only the use of wax as a pattern material will be considered in examining the details of the process.)

As already stated, large numbers of patterns can be produced by injecting wax in the liquid state into a plaster, soft metal or steel die. It is not the intention to describe in detail the method of manufacturing these dies, but mention of the problems particular to this process, the factors governing the choice of die material and tooling costs is necessary.

When molten or plastic wax is injected into a die and allowed to cool, shrinkage takes place. Further, when molten metal is cast into a mould and allowed to cool, shrinkage again takes place. Consequently, the die in which the patterns are to be produced must be made oversize to compensate for this shrinkage, which is in the order of $1\frac{1}{2}\%$ to 2%. In practice, it is usual to arrange for tightly toleranced dimensions to be undersize, so that these dimensions can be accurately corrected by removing metal from the die after a trial casting has been produced.

One of the advantages claimed for this process is the speed with which a complex product can be

made. The axial flow fan blades shown in Fig. 2 were produced in small quantities (up to 60-off of each) in a matter of four weeks, which included tooling. A plaster die was used in this case, such a die being suitable for the production of up to approximately 100 patterns. The cost of a die will depend upon its complexity, accuracy required, size and material used, but generally speaking a plaster die will cost from approximately £5 to £30 for cast components weighing up to 2 lb. Much of this cost goes into the manufacture of a master pattern around which the plaster is formed.

With care, as many as 10,000 patterns can be produced from a soft metal die, but this is dependent upon the accuracy that has to be maintained throughout the run and the number of loose pieces which go to make up the die. Bismuth tin dies are widely used throughout the industry, giving accurate patterns having a good surface finish, and can be readily modified to meet changes in design. A bismuth tin die will generally cost from approximately £15 to £75 for components weighing up to 2 lb. As with plaster dies, a master pattern is required for the manufacture of a soft metal die; these masters may be made of wood or metal.

The decision to use a steel die is not only dependent upon the length of run, but also on the accuracy which has to be maintained throughout the run and the number of loose pieces which go to make up the die. It is obvious that the steel die shown in Fig. 3

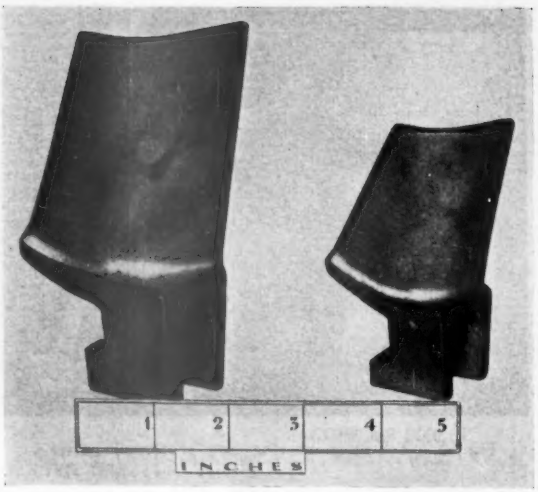
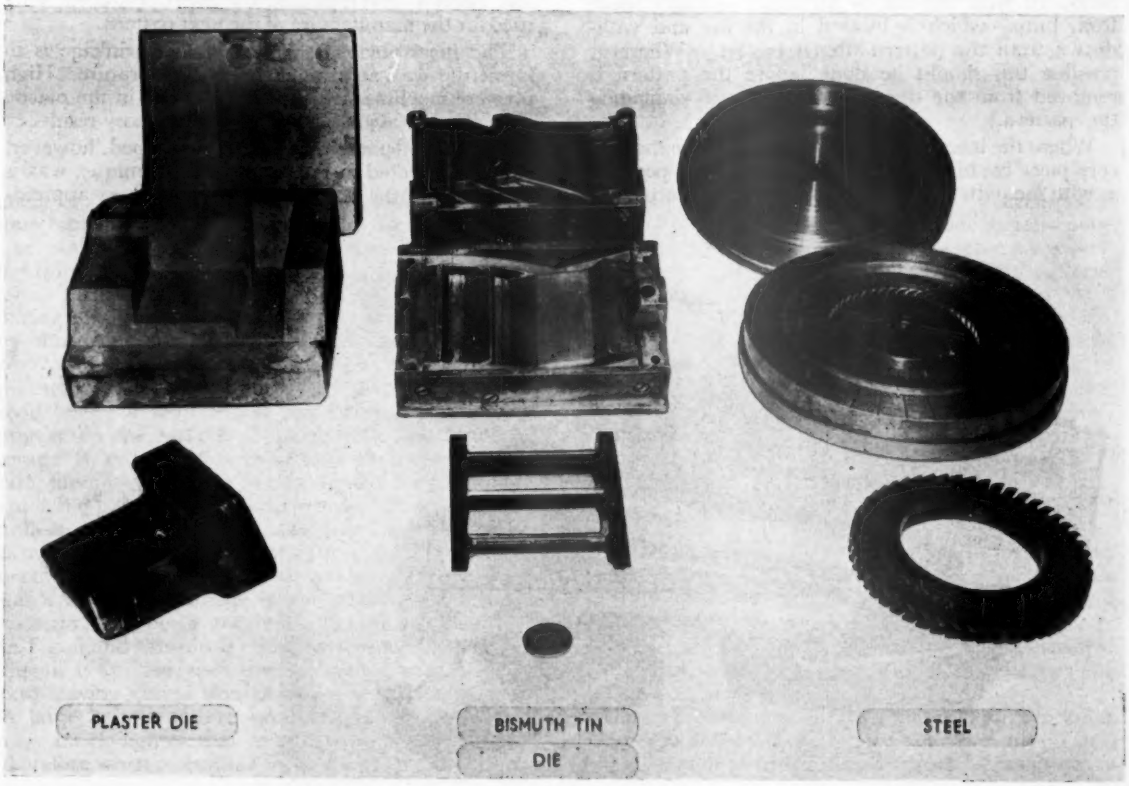


Fig. 2. Axial flow fan blades.

Fig. 3. Wax pattern dies.



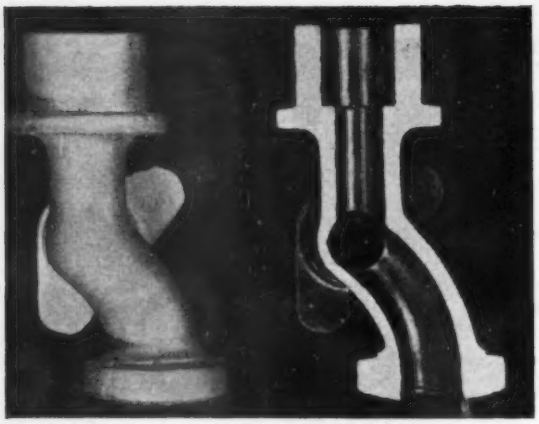


Fig. 4. Tee-piece casting and sectioned pattern.

could not be made in bismuth tin or plaster, because of the large number of loose pieces which have to locate one against the other. It is impossible to give a guide as to the cost of a steel die; a very simple shape can in some cases be produced more cheaply in steel than bismuth tin, whereas a very complex die may cost many hundreds of pounds.

Patterns having a simple internal form can be produced with the aid of an insert—usually made from brass—which is located in the die and withdrawn from the pattern after it has set. (Wherever possible this should be done before the pattern is removed from the die in order to avoid damaging the pattern.)

Where the internal form is of such a nature that the core piece could not be withdrawn from the pattern, as with the pattern shown in Fig. 4, then a destructible core piece is used. This is made by pouring a mixture of molten water-soluble wax and fine sand into a core box. When set, the core so formed is removed, placed in the die and the pattern wax injected around it. When the pattern has set, it is removed from the die and placed in water until the core has dissolved out.

Wax injection dies have also been successively produced by the metal spraying process. The metal is sprayed on to a master pattern to a thickness of $\frac{1}{16}$"-$\frac{1}{8}$" and backed up with plaster, resin or bismuth tin. The two dies shown in Fig. 5 were produced in this manner, and have produced many patterns. They have a lead antimony spray coat backed up with a mixture of resin and sand.

For long production runs, dies capable of producing two or more patterns at one injection are often used to reduce the manufacturing cost.

Injection Technique

The principal problems of injection are concerned with the production of patterns free from surface defects and the control of shrinkage. Various injection techniques have been developed, and machines and tools designed to suit these techniques.

One method employed to reduce and control shrinkage is by the use of wax inserts to reduce the volume of wax injected at one time. This technique necessitates the prior injection of the insert and in order to keep the cost of this double injection to a minimum, dies are made to produce both a pattern and insert at one injection, the insert produced being used for the manufacture of the next pattern.

The most obvious way to reduce shrinkage is to inject the wax at a much lower temperature. High pressure machines which inject the wax in the plastic state are now available and give satisfactory results.

The most flexible method yet developed, however, is that illustrated in Fig. 6. By this technique, wax is injected into the die in the molten state at approxi-

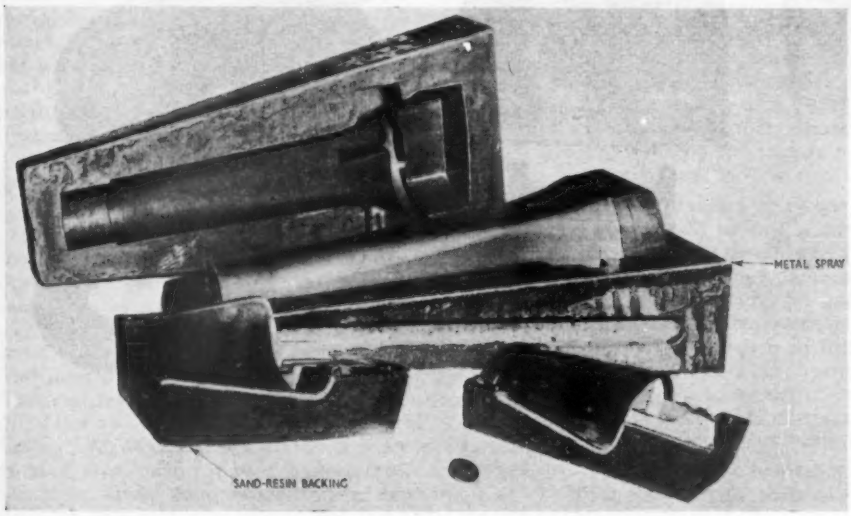
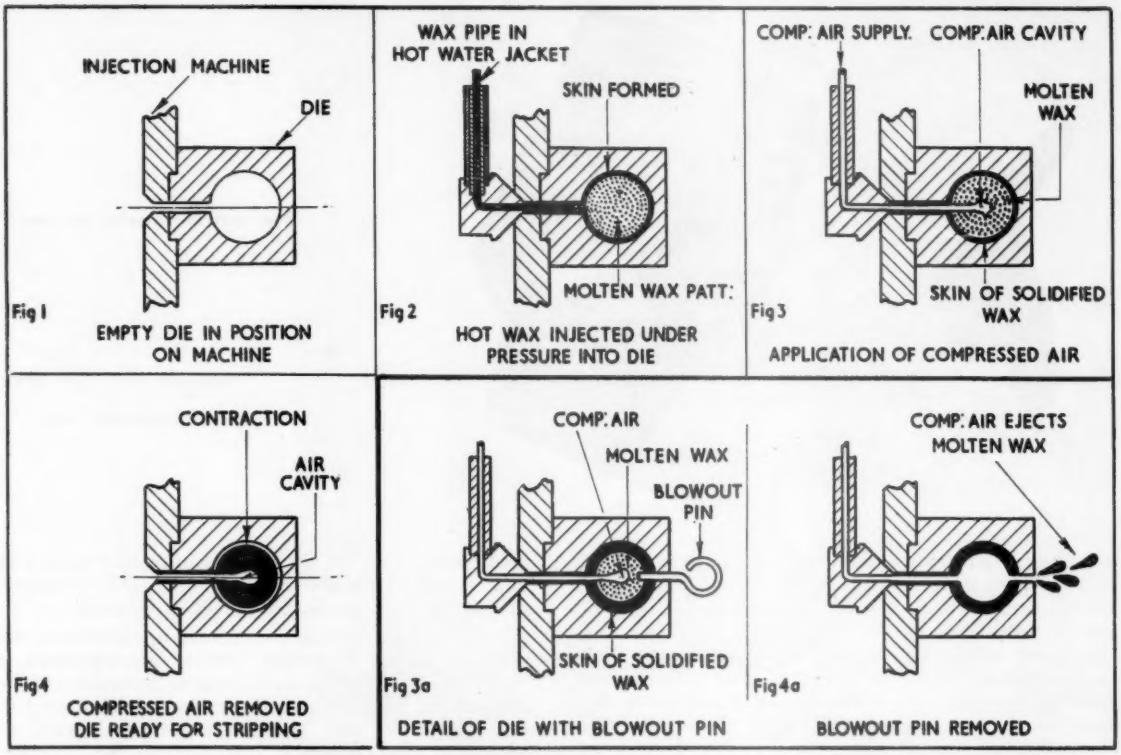


Fig. 5.
Metal sprayed dies.



CYCLE OF OPERATIONS ON INJECTION MACHINE

Fig. 6.

mately 65°C. and 80 lb. per sq. inch, and after a short time lapse air is forced into the wax under pressure. The wax on entering the die immediately starts freezing around the walls of the cavity, and the air forces the flexible skin so formed against the walls during continued cooling. Shrinkage is not eliminated by this technique, but is reduced and very much controlled. The blade pattern shown in Fig. 7 was produced in this manner. If the air is injected too soon before a skin of wax has formed, air bubbles appear on the surface of the pattern and result in scrap. If, on the other hand, the air is applied too late, the injection sprue freezes up and the air cannot enter the pattern. The timing is determined by trial and error, and should be ascertained during the die proving stage; variation in pattern dimensions can occur if these times are not adhered to. This technique has a further advantage in the production of large patterns. If a pin is inserted in the die, as illustrated in Fig. 6 and this pin is withdrawn immediately after the air is applied, then the still molten wax is blown out, leaving only a skin of frozen wax as a pattern. A large hollow pattern produced in this manner is very much lighter than it would otherwise be, and therefore when assembled on to a runner is less likely to collapse under its own weight. Further, the removal of a hollow wax pattern from its refractory mould by the application of heat or a solvent is a very much easier task then the removal of a solid pattern, and less likely to result in damage to the mould.

It is not always possible, or even economical from a tool point of view, to produce very large patterns in one piece. Such patterns are therefore produced in sections and fused together to form the complete pattern. The two-foot diameter stainless steel wheel rim, shown in Fig. 8, was produced from a wax pattern built up using fourteen segmental patterns.

Assembly of Patterns

The patterns are assembled in groups on to a wax runner, which is produced by pouring molten wax into a plaster or metal die. Since the subsequent operations will be carried out on the assembly of patterns, then it is obvious that the more patterns that can be assembled on to one runner, the cheaper will be the cost per component.

Assembly is carried out by fusing the pattern to the runner with the aid of a hot spatula. For this purpose the pattern is provided with a wax sprue, as shown in

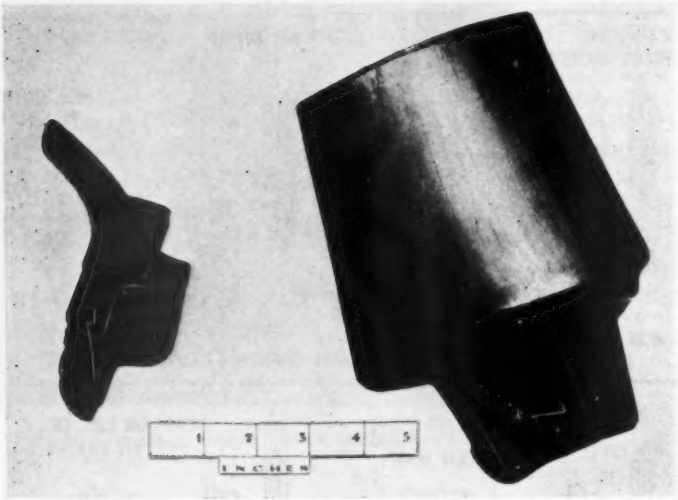


Fig. 7. Wax pattern showing air cavity.

Fig. 9, in order to avoid damage to the pattern during fusing. It is essential that a clean joint is made if casting scrap is to be avoided and to ensure this, and also to reduce the cost of assembly, a technique was developed whereby assembly is broken down into two stages, as illustrated in Fig. 9. The patterns are first fused to sub runners and dipped to just above the level of the joints in molten wax. Then the sub runners are fused to the main runner and dipped in molten wax to just above these joints. This technique provides a quick method of blending the joint.

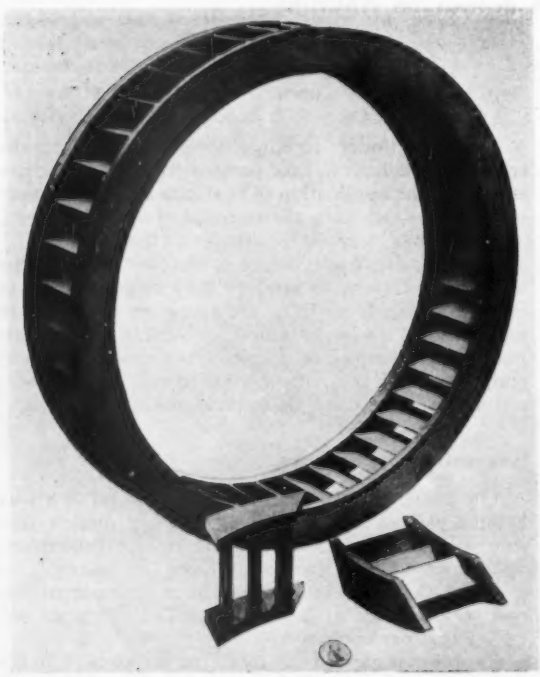


Fig. 8. Cast wheel rim and wax segments.

When a long production run is involved and the component has a simple feeding arrangement, a considerable reduction in the cost of assembly can be effected by using the pouring technique illustrated in Fig. 10. The wax pattern is provided with an elongated sprue which is inserted into the assembly die. Molten wax is then poured into the die to form the runner and at the same time fuse the patterns in position. An assembly unit having four such stations. was introduced for the purpose of assembling compressor stator blades, and by it one operator now does the work previously carried out by three operators. The stations are mounted on a rotating table, so that by the time a station returns to the operator after assembly, the wax has frozen.

As with injection dies, it is essential that assembly fixtures are kept clean and that a parting agent is used to prevent the wax sticking.

As much consideration should be given to the design of the wax assembly as to the design of the component as a casting. Such points as maximum yield, ease of assembly of patterns to runner and also of cutting castings from runner, correct feeding, avoidance of air traps during mould making and of wax traps during dewaxing, and the correct distribution of pressure during casting, all have to be borne in mind.

Mould Making

Having assembled the patterns into a group, the next step is to form a mould around the assembly. It should be remembered that one of the principal objects of the process is the accurate reproduction of complex shapes, and for this reason a one-piece mould is desirable. The mould materials, therefore, must be of such a nature as to enable them to be formed

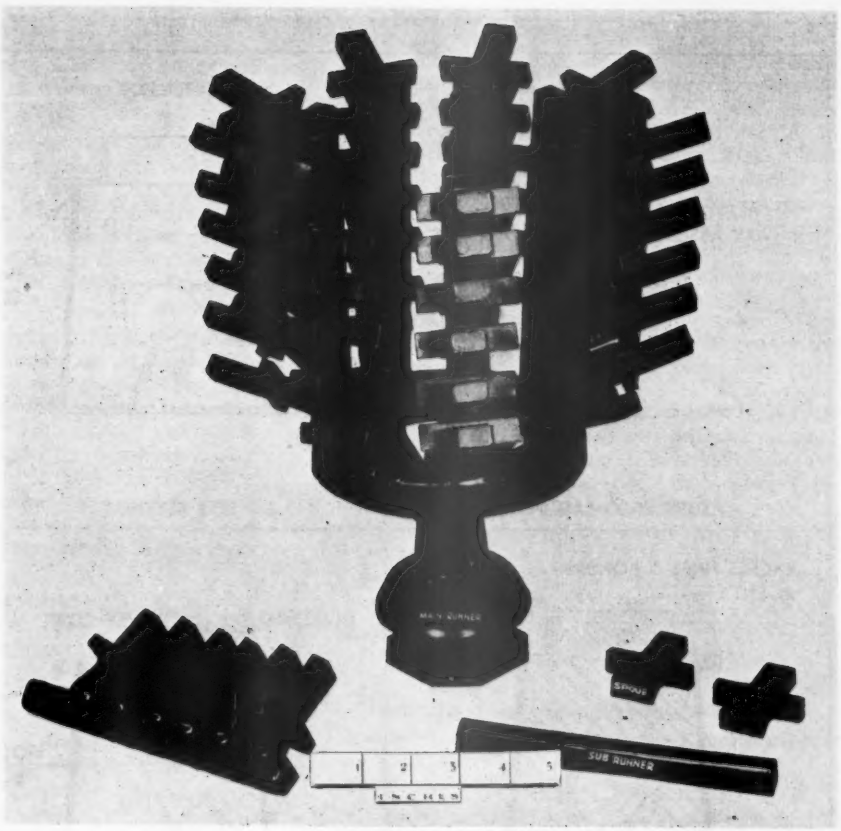


Fig. 9. Wax assembly and sub-assembly.

around a complex destructible pattern, and once formed, to take on a "set" state so that the mould does not collapse when the wax is removed and metal cast in to take its place. Further, the very complexity of many components produced by this process is such as to make the use of risers both difficult and undesirable and, therefore, in order to avoid their use, the mould must be highly porous to permit the escape of gases during casting.

A number of "Lost Wax" moulding processes have been developed which differ mainly as a result of the materials employed, but broadly are of two types:—

(a) solid or block type mould and

(b) shell type moulds.

(The latter should not be confused with the Cronin Shell Moulding Process, which uses permanent half-pattern plates.)

It was the solid-mould technique which was first introduced into industry and remains the most widely practised to-day. By this process, the wax assembly is first given a thin high grade refractory coating. This is applied by dipping the wax assembly into a refractory slurry, allowing excess to drain off and dusting over with grit.

The slurry is made up of a liquid binder and refractory particles such as zircon, silica or alumina. The liquid binder comprises a mixture of ethyl silicate,

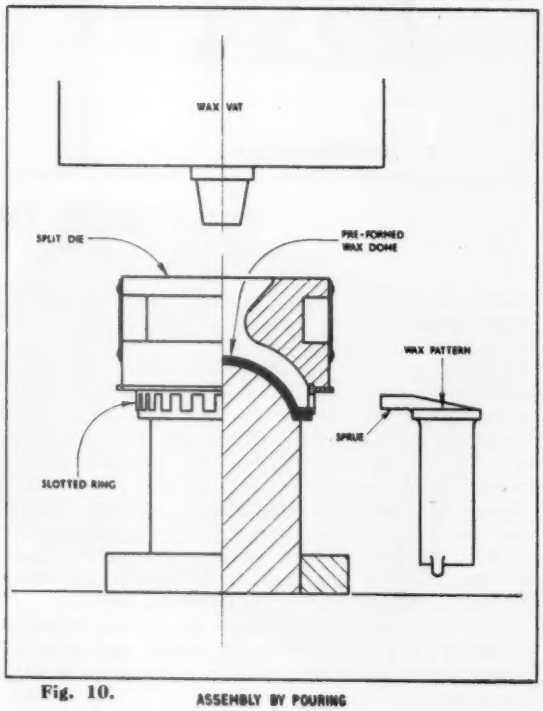


Fig. 10. ASSEMBLY BY POURING

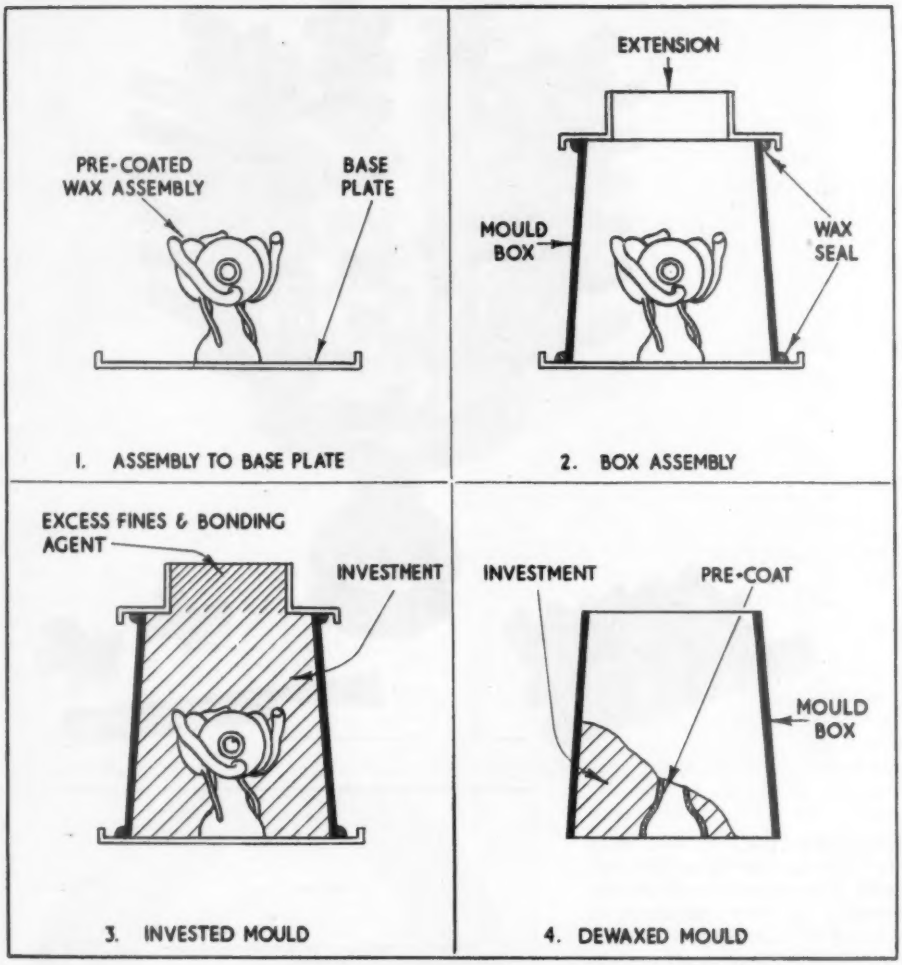


Fig. 11.

SOLID MOULDING PROCESS

water, methylated spirits, hydrochloric acid and a basic oxide. Ethyl silicate is hydrolised in the presence of water and results in the formation of a silica gel, which forms the bond. The methylated spirits serves as a filler and solvent for the water and ethyl silicate, the acid acts as the electrolyte and the basic oxide as the catalyst. The speed of the reaction is governed by the temperature, electrolyte and catalyst, and the strength of the bond by the ethyl silicate. The refractory particles are carefully graded and mixed before being added to the bonding liquid. In order to obtain a good finish on the inside walls of the mould, very fine particles are used—all being capable of passing through a 100 mesh sieve.

The refractory grit with which the dip coat is dusted is coarser than that used in the slurry, and serves to form a suitable keying surface for subsequent moulding operations.

After the dip coating has dried, the assembly is stuck on to a base plate, as shown in Fig. 11, and a mould box carrying an extension piece is placed around it and sealed to the base with wax. The box is then carefully filled—or invested— with a refractory slurry which is basically the same as that in which the assembly is dipped; the principal difference being that a much coarser mixture of refractory particles is used in order to strengthen the mould and give a high degree of mould porosity. The mould is then carefully vibrated, which compacts the particles and causes excess liquid and fines to rise to the top. After the mould has set, the base plate and extension are removed, excess materials scraped away, and the mould allowed to dry out. Care should be taken during the drying out not to let the temperature fluctuate, otherwise the expansion and contraction of the wax will cause the mould to crack. Drying is usually

carried out at about 30°C., in an oven which should be well ventilated to take away the fumes.

In order to reduce the cost of the mould materials, water-based binders—such as sodium silicate—are now widely used to invest the mould.

After the mould has dried out it is immediately dewaxed by slowly raising the temperature to 100°C. in an oven. The wax runs into a well in the floor of the furnace and after being filtered is used for the manufacture of runners. The mould is then placed in a furnace and the temperature slowly raised to 1,050°C., at which temperature any wax left in the mould is burnt out.

This mould making technique involves the careful mixing of considerable quantities of expensive materials. Further, moulds manufactured in this manner suffer from the danger of cracking, due to the difference in the expansion co-efficients of the mould and wax. This results either in the complete failure of the mould or the presence of refractory inclusions in the casting. It was with the object of reducing mould material costs and casting scrap that the Investment "X" or shell moulding process was developed.

By this process, as with the solid-mould process, the assembly of waxes is first given a pre-coat of very fine refractory particles bonded together. The binder used in this case, however, is Syton C, which by careful mixing with the other ingredients results in a thixatropic mix. Such a mix gives an evenly distributed pre-coat on dipping and does not need dusting over with a grit. This mix will last over a very long period without gelling and can be topped up as necessary.

After the pre-coat has dried, a further six to eight dip coats are applied using an ethyl silicate bonded mix. Each dip coat is dusted over with a grit and dried by placing the assembly in a circular wind tunnel, which dries each coating by the time it returns to the operator. In this manner a shell approximately $\frac{3}{16}$ in. thick is built up around the wax. The wax is then removed from the mould by dissolving out in hot trichlorethylene vapour—a degreasing plant being used for this purpose. Fig. 12 shows the dewaxing bath, and Fig. 13 the mould at various stages of manufacture. The dissolved wax falls into the bottom of the bath in solution with the trichlorethylene and is recovered by bubbling air through the solution. This liberates the trichlorethylene as a vapour, which is condensed and drained off from the plant. After filtering, wax recovered in this manner is used for the manufacture of patterns. The shell is then placed in a metal canister and, as in the case of the solid mould, fired at a temperature of 1,050°C. If the shell is to be centrifugally cast, or is of such a nature as to require support, then it is invested with a loose refractory grit before firing. For this purpose, crushed shell recovered from cast moulds is used with a half-inch covering layer of sand, which—due to the presence of clay in the sand—forms a retaining seal when fired.

The advantages of the shell mould over the solid mould are as follows:—

(a) The assembly and stripping of baseplates, mould boxes and extensions is eliminated.

(b) The storage, handling and mixing of mould materials is very considerably reduced.

(c) The cost of mould materials is reduced by as much as 75%.

(d) The need for vibrating tables is eliminated.

(e) Mould drying is simplified and the danger of explosion removed.

(f) Dewaxing by dissolving in hot trichlorethylene

Fig. 12. Trichlorethylene dewaxing vat.

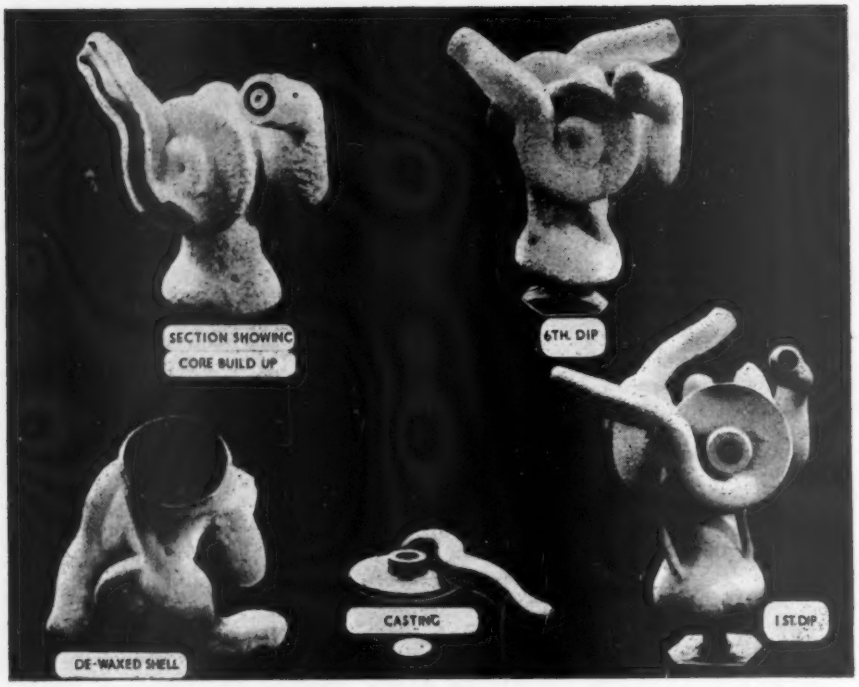
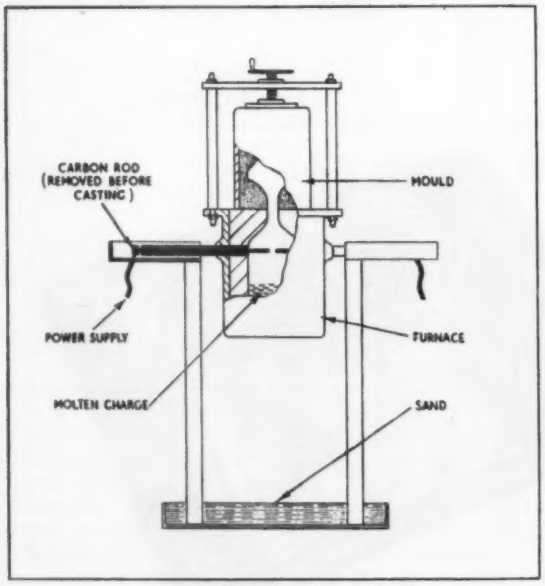


Fig. 13. Shell mould at various stages of manufacture.



GRAVITY CASTING OF SOLID MOULD

Fig. 14.

fumes not only eliminates the danger of cracking, but also ensures the complete removal of the wax.

Scrap resulting from refractory inclusions and mould failure is therefore reduced.

(g) The mould has a much higher degree of permeability.

(h) Progressive solidification can be readily achieved by cooling parts of the shell with an air stream and by varying the loose investment.

(i) A mould of constant texture on all faces is ensured.

(j) The castings can be readily removed from the mould.

(k) The simplified process permits an increase in output.

(l) Capital expenditure is reduced.

Casting

The melting furnace and method of casting steel into a solid type mould differs from that when a shell mould is used. In the former case, a 12 or 25 KVA. indirect arc furnace mounted on trunnions and capable of melting 5-10 lb. of steel is used. When the charge is ready for casting, the mould is brought from the firing furnace and clamped on top of the arc furnace, so that the mouth of the mould is in line with the furnace aperture—as shown Fig. 14, and then inverted so that the metal runs from the furnace into the mould. In the case of a shell mould, the loose investment used to support the shell does not permit

the mould being inverted and consequently an arc furnace having a pouring lip is used, the metal being poured from the furnace into the mould. Alternatively, the metal is melted in a much larger furnace, tapped off into a crucible and then poured into the mould. With non-ferrous metals, the charge is melted in a gas fired furnace and poured direct from the crucible.

Regardless of the type of mould or furnace, it is important that the metal is cast into a hot mould. In the case of steel a mould temperature of 1,050°C. is used, and with non-ferrous metals 600-800°C. The mould should be at an even temperature throughout, and for this reason firing takes from 3 to 5 hours. The object of casting into a hot mould is to reduce the thermal shock during casting and ensure a metallurgically sound product.

The process is mainly used for the production of highly stressed steel castings and for this reason every precaution must be taken to ensure the quality of the product. The casting stock is normally fed into the furnace in bar form (about $\frac{5}{8}$ in. dia. by 2 ft. long), which feeds itself into the furnace under the action of gravity as melting proceeds. A colour code is normally used to identify the stock on the shop floor, and the supplier's batch identification number is recorded on a melt sheet. As will be seen from the sheet shown in Fig. 15, the day's melt and each mould is given an identification which is eventually transferred to the castings, thus enabling the conditions under which each component is produced to be traced back should the need arise.

The casting temperature in the case of steel is above 1,450°C., the exact temperature being dependent on the material to be cast, the mould, the component and the casting technique.

DATE 5-6-52 MELT NO. 1413

MOULD NO.	FURNACE NO.	DESCRIPTION	IDENTIFICATION	MATERIAL	BATCH NO.	CHARGE	SILICON ADD.	CHROME ADD.	OTHER ADD.	MOULD TEMP.	METAL TEMP	SPEED R.P.M.	INITIAL CARBON WEIGHT	FINAL CARBON WEIGHT	CARBON CONSUMPTION	PRE-CASTING TREATMENT	INSPECTION SIGN WHEN CHECKED	NO. FROM KNOCK-OUT	NO. FROM INSPECTION	REMARKS
1	A	7429 BLADE	A-R	S 80	12071	12 lb	1 OZ	4 OZ		1000°C	1570°C	250	16.4	15.5	.9		SA	17/18	17/18	FOR ANALY:
2	B	"	$S-J^1$	"	"	"	"	"		"	"	"	12.1	11.35	.85		SA	18/18	17/18	
3	C	"	K^1-B^2	"	"	"	"	"		"	"	"	14.1	13.1	1.0		SA	18/18	18/18	
4	A	"	C^2-T^2	"	"	"	"	"		"	"	"	15.5	14.5	1.0		SA	18/18	18/18	
5	B	"	U^2-L^3	"	"	"	"	"		"	"	"	11.35	10.3	1.05		SA	16/18	16/18	

MELT SHEET

Fig. 15.

Fig. 16. Centrifugal casting.

Fig. 16 shows a mould being centrifugally cast. The mould is clamped to the casting table, a safety cover placed in position and the metal poured in while the mould is rotated. The speed of rotation is dependent on the component being cast, but is generally in the order of 250 r.p.m. This technique gives a better pressure distribution during casting and a higher yield.

Casting and the subsequent operations may be described as a reversal of the events up to casting:—

(1) Prepare wax patterns
(2) Assemble patterns
(3) Form mould around patterns
(4) Remove wax from mould
(5) Fill mould with metal
(6) Strip mould from casting
(7) Cut-off castings
(8) Dress castings

Stripping the mould materials from around the casting is a comparatively simple task in the case of shell moulds. The loose investment is tipped out and the shell removed by hammering the runner, which causes the shell to shatter. In the case of a solid mould, the investment has to be carefully hammered away from around the castings.

The assembly of castings is then shot-blasted to remove any investment still adhering to the metal and each component cut-off using a high-speed slitting wheel. The components are then dressed, given a final light shot-blasting and the casting identification number stamped or etched on.

Quality of Castings

As already stated, the process is generally used for the manufacture of highly stressed steel components, which are therefore subjected to a very stringent inspection. For such components this generally necessitates a 100% X-ray examination for internal defects, a 100% visual examination for surface defects, and a percentage chemical analysis.

The scrap percentage for such components might therefore be expected to be high and is so compared to less critical castings. Fig. 17 shows a compressor stator blade in stainless steel and a carbon brush holder in brass. An average overall scrap of 15% (of which 7% is X-ray scrap due to refractory inclusions or microscopic porosity) can be expected in the former case and less than 7% in the latter case. This blade has a fairly constant section along the blade length, which does not aid progressive solidification of the metal from the tip to root and therefore increases the danger of scrap due to porosity. In such cases, progressive solidification can be assisted by cooling sections of the mould prior to casting.

The nature and extent of the scrap will vary considerably with the function of the product. With many components where a finish one hundred per cent. free from defects is required, scrap may be mainly due to surface defects. If not resulting in scrap, such defects can add considerably to the cost of manufacture as a result of increased time spent on dressing. A matt finish of 80 micro inches is obtainable by this process, which is extremely good for casting but does not compare with a good machine

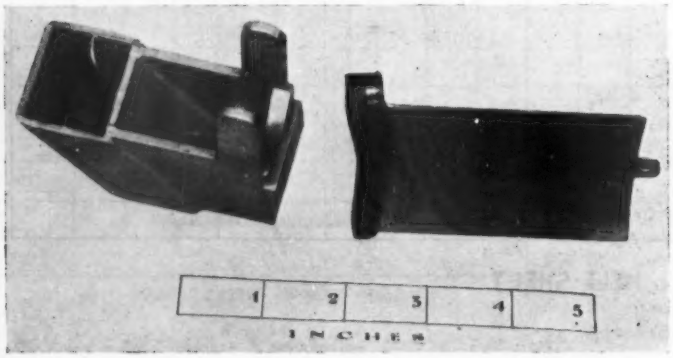


Fig. 17. Cast brush holder and compressor stator blade.

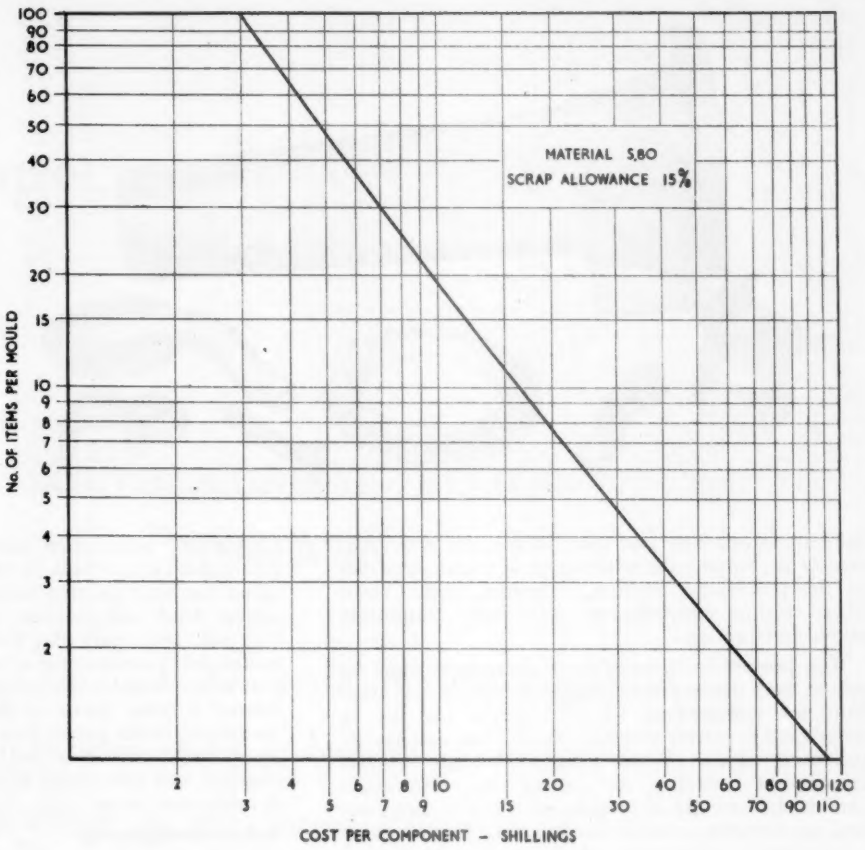


Fig. 18. CASTING COSTS ~ EXCLUDING DRESSING

finish, and it should be remembered that this is a casting process. On a production basis casting accuracies of $\pm$.005 in. per inch are obtainable in all planes, but this figure is influenced by the shape of the component. With a long thin sectioned casting, distortion along the length may cause the error to be considerably in excess of this.

Cost and Application

In comparison with sand casting the "Lost Wax" process is very expensive, but like all other processes has particular fields of application. Fig. 18 gives a guide as to the cost of producing the raw casting and is based on a furnace capacity of 14 lb. Approximately 50% of the charge will be required for feeding purposes and therefore for a component weighing half a pound, fourteen components can be cast in one mould and will cost approximately twelve shillings each in S.80. The shape of the component also influences the number of items that can be cast together, but will not be in excess of the number based on the weight. It must be emphasised that this is only a guide and each job should be judged on its merits in comparison with other methods of manufacture.

To the cost of casting must be added the cost of dressing and finish machining. This charge is negligible in many cases (as with the brush holder shown in Fig. 13), but in others where a high degree of accuracy and finish is required (such as with the blade shown in the same plate) this charge may exceed the cost of the raw casting. If the nature of the job is such as to require a considerable amount of finish machining, then generally speaking it is more economical to machine the component direct from the solid.

This process really comes into its own for the production of complex shapes where the as-cast surface finish and accuracy is good enough—as in the case of the wheel rim shown in Fig. 8, which only requires the diameters and faces of the flanges to be machined.

One of the earliest applications of the "Lost Wax" process was the production of components in metals

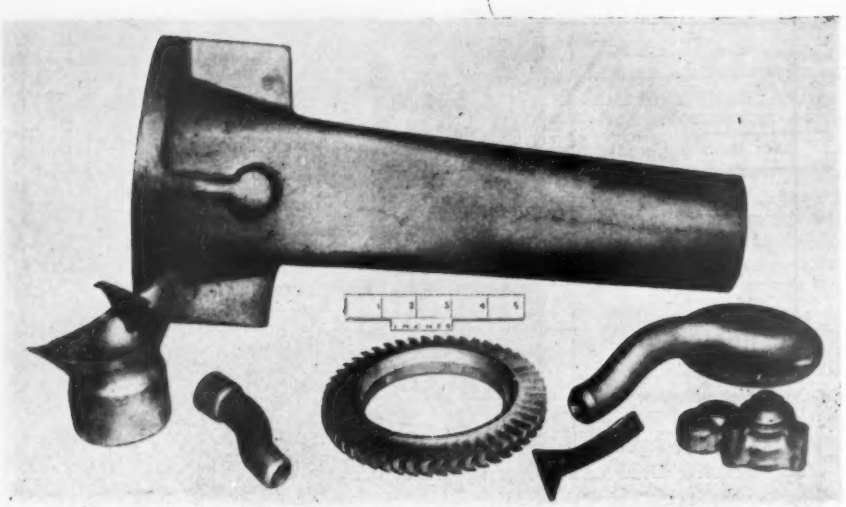


Fig. 19. Miscellaneous steel castings.

difficult to machine and this still remains an important field. Among the wide range of metals now cast by this process are Stellites, Nimonics, H.R. Crown Max, chrome molybdenum, S.G. Iron, aluminium alloys and brasses.

The process has a number of advantages from the design and development engineers' points of view. Complex components which hitherto had to be redesigned to permit or reduce machining, can now be produced closer to the designers' ideal without considerably affecting the casting cost. Prototypes can also be very quickly produced at low tooling costs and modifications readily carried out. Fig. 19 shows a number of components which it is considered are more suitable for production by this process than by other methods of manufacture.

Over the years since this process was introduced into industry, the bulk of development work undertaken has been devoted to reducing scrap, improving surface finish and reducing mould material costs. In the past few years the process has become more settled and process control has resulted in a considerable improvement. At the present time, considerable interest is being shown in the possible application of the process to the production of steel castings weighing up to one hundredweight, particularly thin-walled castings, and with many firms this will form a major development project over the next few years.

Acknowledgments

Acknowledgments are made to the Directors of Metropolitan-Vickers Electrical Company Limited, for permission to publish this Paper.

"TRACER-CONTROLLED PANTOGRAPHIC MILLING" — concluded from page 763

sensitive tracing spindle with which the most delicate designs can be traced. The movement of the cutter is influenced by a 2 to 1 ratio pantograph. No gearing is used, hence, no backlash. Fig. 14 reveals one of the intricate designs obtainable.

Recently a transfer-type pantograph machine (Fig. 15) has been developed to accommodate high-production-run parts. The machine incorporates four complete pantograph mechanisms and a 48 in. diameter automatic indexing rotary table. It may be readily noted that four different operations may be performed on a given part, roughing and finishing operations, or one operation on four parts at one time completely automatic.

Modification

There is one more unusual advantage of the pantograph method which must be mentioned. This advantage results from the fact that the pantograph principle, on the one hand, can be readily adapted to varying requirements and, on the other hand, reduction ratio can be employed for certain classes of work without the pantograph mechanism. When the latter method is used, a much more accurate machine can be designed. In this case, the pantograph linkages are not required; instead, a pivoting beam is employed. It is probably already apparent that part of the pantographic method of reproduction can be used in order to employ reduction ratios in the machining of work pieces or cams. Fig. 16 shows that the reduction ratio results from the relative position of the cutter spindle to the fixed tracer spindle. If the milling head is moved out toward the tracer spindle, the reduction ratio is reduced due to the fact that the arc formed by the swinging cutter spindle is more nearly of the same radius as the tracer spindle arc. When the milling head is moved back towards the pivot centre, this ratio is increased, and the arc formed by the cutter spindle is of much smaller radius than that of the tracer spindle. This much of the pantographic reduction principle was made use of in this contour milling machine.

"Aspects of Automation"

NORTH MIDLAND REGION CONFERENCE

In June this year the North Midland Region of the Institution held a one-day Conference at Peterborough on the theme "Aspects of Automation". The six Papers presented on this occasion appear on the following pages.

The Conference was opened by the Mayor of Peterborough, and the chair was occupied by Mr. E. W. Hancock, M.B.E., now President of the Institution.

AUTOMATION

by ARTHUR GRIFFITHS, O.B.E., M.I.Prod.E., M.I.W.M.,

Director and General Manager, Daimler Company, Ltd.

SELDOM in the history of conferences can there have been such a coincidence of events where on the one hand, a serious professional Institution decides to choose for its theme at its Regional Conference the subject of Automation, and in the months preceding the Conference, the public is treated to prolonged and bewildering front-page publicity in the daily Press, displaying the best and the worst of our modern journalists' sense of what is "news". The car manufacturing world is disturbed by unfortunate developments, and consequent labour problems, and industry in general wonders what it is all about, and what is the "Revolution" that is taking place.

One thing is certain. If we have ever coined a word calculated to rouse antipathy, misunderstanding, and mistrust, it is this word, "Automation", which is on the lips of every man, woman and child to-day.

An Unfortunate Choice

In the first place, it is suggestive of all that is abhorrent in the outlook of any man seeking to find expression for his thoughts and talents, and a way of life which can use the great resources which man's ingenuity has so far placed at his disposal. It is suggestive of "automatons" and indeed the natural corollary to this is the "robot" in the language of the popular Press. I suppose that such a word was inevitably bound to arise when dealing with a combination of automatic processes and instrumentation. The imaginative mind immediately rushes forward to visions of an overnight transformation in the sphere of production, eliminating the means of earning a livelihood, and reducing factories to soulless halls of efficiency, smoothly performing the work without human aid or skill.

Since the dim beginnings of mankind, the human brain has been busy devising easier means of performing the simplest and smallest number of tasks necessary to sustain himself, and to provide what he considered necessary for his health and his pleasure. A few decades ago, the motor car was outside the ken of the normal man and was scarcely one of his wants. The washing machine, the cake-mixer, the radio and television set, were high flown dreams which could never have become a feasible factor in the life of man if it had not been possible to make them cheaply, quickly, and in sufficient numbers to be attainable. So it is with thousands of commodities, foods, and the general paraphernalia of modern life. The product of our inventors' brains is useless if it cannot be placed within the reach of the potential user.

And so, to put it briefly, industry of every kind has been busy since its inception in devising ways and means of producing in less and less time that which appeals to one section of the community or other.

It is true that the most spectacular examples of progress in this way have been perhaps the working and fabricating of iron and steel, and the preparation of materials from animal or vegetable matter, that is, textiles and chemicals. We have seen this process develop during the last fifty years or so in the form of sub-division of the work necessary to be done into its smallest elements, with the following objectives:

(a) to simplify the task so that it can virtually be performed by anyone without inherent talent or specialist training or undue effort;
(b) to ensure that each and every piece of work shall be repetitive in quality and in form;
(c) To enable greater numbers of the product to be made available.

Each of these requirements has caused the evolution of highly specialised tools and equipment, devoted to one special purpose, to which human hands have fed material in an appropriate manner and then passed it on to the next pair of hands.

One Major Problem

To-day, we are left with one major problem. We have created so many individual processes, spread over so many kinds of products, and we have developed such an insatiable thirst for more and more of these products, in the home, in the field, and in all spheres of life, that there simply are not sufficient pairs of hands left to operate all these processes unless we provide the missing link.

In effect, wherever goods and commodities are produced repetitively, the people that feed, and pass, and receive, are handlers. Handling is the real factor of direct production costs to-day, and it is only in the last ten or twelve years that we have seen the attack on this problem developing. This process of inserting

handling equipment between all the processes is what the world has now been taught to call "automation", and true production engineers have been busy "automating" their processes for fifty years or more.

If an article will roll, we have let it roll from one place to the next on an incline. We have elevated it, if necessary with power, in order to achieve this. We have pushed it sideways, downwards, and even blown it with air from place to place if circumstances were suitable and, in fact, we have done anything to avoid carrying it.

A Startling Process

Now what has turned this well-known, and widely practised, process of elimination of human effort into the terrifying and startling process of automation?

Rather less than a year ago, the Institution of Production Engineers staged a National Conference at Margate, which really tabled and put on show the progress which had been made in the scientific world towards harnessing the science of electronics to the mechanics of industry and commerce. Sheer mechanical movements had almost reached their peak limit to which they could be applied, in terms of sensitivity and relative cost. Electronics applied to the actuation of remote mechanical movements with sensitive discrimination, and lightning computation, paved the way to co-ordinating a vast array of mechanical movements which were formerly only to be controlled by comparatively clumsy and slow methods, using mechanical, hydraulic, or pneumatic, forces.

The mechanical engineer has been quick to seize the opportunities which this affords of linking together the many processes which formerly had to be regarded as essentially separate entities. For the purposes of this short Conference, we must confine ourselves to local interests and implications. Therefore, we can only touch upon those aspects which are of special interest to this Region. Let us ask ourselves what automation is going to mean to our industrial life as we know it.

In the mechanical engineering world there is a sharp line of demarcation between those who produce goods in large quantities of a repetitive nature, and those who produce individual units, virtually tailor-made, for special purposes. I think it can be taken for granted that our interest centres on the first bracket for the time being, as potential users of such equipment. In a city like Peterborough, for example, there are perhaps two or three cases covering the manufacture of electrical equipment, sugar, and engines where true automation in the factory already exists and will expand.

On the other hand, perhaps, it is true that in this brief survey, too much emphasis is apt to be placed on the large scale production aspects of automation, ignoring the equally important, but less spectacular, application of electronics and the computer to an individual machine. Here, as distinct from the linking up of many processes and machines, we have the co-ordination of a single machine's movements in three planes capable of being governed by a predetermined programme inserted into the controller unit of the machine. This can transform the production of expensive machined parts even in quantities of one, two or three pieces.

On large scale production the term "automation" has brought with it another term, i.e. transfer machine or transfermatic. The word "transfer" is far more intelligible, and implies the very process of handling, which is the basis of automation, and enables the series of machine tools formerly placed close to each other, but separately, to be linked together as one integral unit. The research, development, and application of this principle over recent years has been chiefly responsible for establishing certain fundamentals which are essential for success. Emotional journalistic lingo talks blithely of mechanical "brains"; there are no "brains" inside automation. The automatic machine will make scrap as quickly as it will make good work, unless it is protected. Therefore, we have seen automatic inspection and sensitive protective devices introduced to prevent the machine from wrecking the economy which it is designed to produce.

Underlying the whole principle of this topic is the fact that all goods, commodities, and devices, which mankind now deems to be essential to his well-being can all be assessed in terms of man-hours required to produce. If more of these goods, or greater variations of them, are wanted and all our hands are full, there are only two ways to get them. One is to work more hours in a day, and the other is to improve the speed with which they can be produced. But everyone wants to be engaged less hours per day, and have more time to enjoy the fruits of our inventive resources and productive ability. For it must be remembered, we are not producing goods for some bottomless pit, but we are producing them for ourselves and others like us to use. And what we cannot make for ourselves, others must make for us.

Therefore, if means to produce are speeded up, it might follow that in a well-balanced world, we should all find it possible to make our contribution in less time and enjoy the fruits of our labours.

The Past 50 Years

One has only to review the industrial life of our community over, say, the last fifty years and compare the working hours and the corresponding amenities with those of to-day. Roughly speaking, the working day is one-third less, and the amenities in the home, at work, and available for leisure, are immeasurably greater. All this has been achieved without great upheaval because the rate of change has been gradual. But, in thinking like this, we must remember, too, our own particular place in the world both geographically and commercially. For the time being, our very existence depends upon ability to export our products. We cannot live on our own fat. Higher standards of living accompanied by shorter hours of work can only be achieved *as a result* of higher productivity. *They cannot precede it.* We must have the means at our disposal, as good as, or if possible better than those of our competitors, for placing our goods anywhere in the world in exchange for so many essentials for our way of life.

Let us not blink our eyes to the fact that the transition period or rate of change is a most important factor. There is no warrant for drastic change, involving wholesale disruption of labour, and throwing up unwanted hands. For it should be obvious that our total economy demands that all hands should be employed in performing useful work, otherwise the benefits derived from progress of this kind are dissipated in supporting those who are idle.

Another important problem is the equality of distribution of the benefits from increased mechanisation over all occupations. We are apt to think as engineers, being engineers by profession. But of what avail is it going to be if we see the engineering trades, for instance, achieve an ever-increasing economy of effort until its members could quite well produce in half the man-hours required to-day, all the goods demanded, when another trade lags behind and must be absorbed for longer hours in meeting its corresponding demand? We have seen something of this problem in the relative progress in mechanising agriculture, as compared with the more finite problem of mechanising the engineering world.

There is no doubt that we have many problems ahead of us and the most important is going to be the human problem. It should be obvious, however, that the trend must be towards elevating the general level of attainment in skill and craftsmanship. Behind this array of mechanisation must follow an ever-increasing army of technicians, draughtsmen and scientists. Every responsible man should be devoting some of his thoughts towards the problem of cultivating a much higher proportion of trained youth, needed in the future to design, maintain, and to manufacture these tools and machines if they are to bring the benefits to mankind which we think they should. In the meantime, the resources and possibilities lying at the hands of bold and enterprising engineers must be accompanied by wise, considerate, and careful planning in terms of human factors. As one of our foremost members, Sir Walter Puckey, said last year at Margate, "The post-war campaign for higher productivity will come to a grinding halt if actual production (and therefore actual employment) appears to be limited." How true this was shown to be in the recent strike in the Midlands! That was not a strike against automation, but against the way it was being put over and the immediate local and short term effect. Therefore, every responsible man down to the Departmental Manager has got to help first, by studying carefully for himself the true long-term meaning of progress in productivity, finding out why it is essential to our very existence, let alone a higher standard of living, and then passing it on to every individual worker with whom he is in constant contact, so that we all can go forward in unison and with courage to play our part in this accelerated age of progress.

AUTOMATION IN THE TEXTILE INDUSTRY

by Dr. C. H. EDWARDS, M.A., F.T.I.,

Head of Department of Textile Studies, Nottingham Technical College.

MANY of you may be wondering why the subject of textiles should be appearing on the programme of a Regional Conference of engineers, and I feel that some word of explanation should be given.

The idea for this lecture arose from a visit to the Department of Textiles by the members of your Nottingham Section, as an item in their winter programme of activities. Those present were highly interested in the degree of complexity and automaticity attained in modern textile machinery, particularly in many of our knitting machines, and suggested that information on this point might prove equally stimulating to those engaged in the manufacture of more prosaic machines.

When I accepted this brief earlier in the year, I was not in a position to know that my topic was also to be the subject of a comprehensive article in the April issue of your Journal. I hope that most of you have read this contribution on automation in the textile industry, because it is undoubtedly a valuable and well-illustrated review of the subject and I should like to congratulate its author, Mr. Thompson, on the skill and effort which have so manifestly gone into its compilation.

Fortunately for me, the author left untouched the subject of knitting and hosiery machinery and I have, therefore, switched my talk to deal primarily with these matters. Before commencing with technicalities, I should like to say a brief word on the interpretation and meaning of automation. To many it consists in

the linking together, by automatic transfer and control, of a sequence of individual processes carried out substantially on a series of different machines. To others, and this applies particularly to the design and building of knitting machines, automation means the development and evolution of a single machine which can carry out all the individual operations required to produce a complete garment, the sequence and spacing being controlled by a mechanical device such as a chain or a selector card with punched holes or by some form of electronic device.

It should also be understood that knitting machines are divided into two main classes: those which produce fabric of some constant width, which may later be cut up and made into garments and those which produce garment shapes or almost completed garments during the knitting operation. It will be evident that the degree of automation possible in the former class is limited in extent to that possible in the weaving industry. The knitting elements are provided with various types of selecting devices which can be automatically controlled to produce numerous types of design by the introduction of stitch effects, or colour, or both together.

Increasing Automation

By contrast, the degree of automation reached in the garment making machines is very high and is still proceeding steadily day by day. The development can most readily be followed by studying the history of a particular type of machine, and the modern fully fashioned stocking machine probably provides the most interesting illustration.

Until the reign of Queen Elizabeth I, knitting was carried out entirely by hand on pins, each row of loops across the garment being held on a pin and knitted off successively. The invention of the hand frame by the Rev. William Lee at Calverton, near Nottingham in 1589, inaugurated the machine era. His genius produced the bearded needle, having a spring hook which could be closed by pressure to allow a knitted loop on the stem to slide over the hook and be cast off. By mounting a row of such needles in a bar, one for every vertical row of loops in the fabric, he was able to produce a whole course of knitted loops by one small group of operations and so made fabric at a then incredible speed. By contrast, it may be noted here that a modern warp knitting machine can produce nearly five million knitted loops per minute. Lee was also able to shape his fabric, as required by the ultimate garment, by the hand transfer of loops from one group of needles to another, this process being known as "fashioning".

Various refinements were added during the next three centuries: the use of dividers to improve fabric quality, the automatic thread carrier which saved one manual operation, automatic fashioning whereby a whole group of threads was collectively lifted from the needles by a set of points, moved in or out by rotating a screw thread and replaced on the required needles, thereby greatly saving time.

The culmination came with William Cotton's patent of 1864. He analysed the motions of all the various parts, needle bar, sinker bar, dividers and catchbar, resolved each into its horizontal and vertical components and reproduced them by a pair of cams for each motion, all the cams being mounted on one shaft which could be rotated by hand or power. Each revolution of this shaft thus produced a row of knitted loops and speeds of 40 rows per minute were soon attained. The fashioning mechanism was also added to this Cotton's Patent Frame, as it was then christened, and was driven from the same camshaft but was put in and out of use by hand as required. The use of mechanical power drives enabled wider machines to be built, producing six, then eight, exactly similar garments simultaneously side by side.

Although the machine now did so much, the whole sequence of operations was still controlled by the knitter and called for considerable training and skill on his part. He had to collect the first row of loops from each head of the machine on a welt bar and transfer them back to the needles at a later stage, thereby turning the welt of the stocking; to change the yarn for the various parts of the hose by changing the carrier selection; select suitable fashioning intervals for narrowing the stocking, putting the mechanism in or out of action as required and racking the transfer points to the right position between their various times of use; introduce the splicing or reinforcing thread carriers for the heel and foot at the right time and control the respective lengths of the various parts of the garment by counting courses or measuring. Since a stocking, though made from flat fabric, is essentially a three-dimensional article when in use, it was then found impossible to make the entire garment on one frame and two separate sets of frames, known as "leggers" and "footers", had to be employed. In addition, various ancillary operations such as "running on" and linking had to be carried out at intermediate stages before the shaped fabric could be finally seamed into its finished tubular shape.

Peak of Performance

Over the ensuing years, these various operations have successively been automatised, reaching the peak of performance in the modern single head machine. The main sequence of operations is set out in lines of cams screwed to the periphery of a control drum, each line controlling one type of operation. The control is racked round intermittently by a clawker and bluff mechanism and makes one revolution per stocking. The bluff is controlled in turn by a long chain carrying a line of studs spaced according to the lengths of the different parts of the garment. The chain also carries other lines of studs which operate ancillary mechanisms, such as yarn carrier selection, fashioning mechanisms and splicing contours.

Shortage of skilled labour for linking operations, which are particularly difficult on fine gauge nylon hose, has caused the introduction of the so-called "loopless" toe, in which the hose is narrowed finally almost to a point and only seaming is required as the final operation.

The use of two separate machines has similarly been overcome by the introduction of the round heel,

whereby the fabric at the heel is widened on either side and then rapidly narrowed again. After seaming, this construction produces a shaped heel pouch which is entirely satisfactory if made in a plastic yarn such as nylon, which can be shaped during the finishing process.

The only attention needed by the operator is to insert the welt bar, swing down the picot bar and start the machine. The machine stops automatically at the end of the welt, the operator presses in the welt bar and transfers the loops, attaches the weight straps and restarts the machine, which then knits the entire leg and foot, resets itself ready for the next hose and automatically stops. In consequence, these machines can now be tended by semi-skilled and female labour.

Alternative to these single head machines, there have been big developments in the multi-heads which now make 28, 30 or even 32 stockings at once. Completely automatic welt turning is now standard on all these machines, although one or two other controls are still manually operated and a greater degree of responsibility rests on the knitter, who is a highly-trained and well-paid employee.

A Similar Development

A similar development of automisation may be traced in the history of the seamless half-hose and hose machines, which consist essentially of a series of needles placed in equally spaced vertical slots cut on the outside of a vertical cylinder. The needles are displaced in turn vertically upwards and downwards by means of cams which rotate relative to the cylinder and operate on butts attached to the needles. The fabric is produced in tubular form and passes down the centre of the cylinder.

Essentially a sock consists of a welt, which prevents unravelling and gives a neat top edge, a short length of fine rib, the main leg which may be plain or ribbed stitch, pattern in stitch or colour or merely plain, a heel pouch formed by taking needles successively out of action and returning them similarly, a foot which has a plain sole and perhaps a patterned top similar to the leg, and finally a toe which is made in similar manner to the heel. In addition, splicing yarns may be introduced in the heel, toe and foot bottom for reinforcement against wear and horizontal and vertical colour stripes may also be required.

Mechanisation started by dividing the whole operation into two parts. The rib tops with welts were produced in continuous sausage form on one machine. Each one was severed, a marked row of loops picked up on to points and thus transferred to the needles of the second machine which produced a plain leg, a heel and a toe. The shaping of heel and toe was achieved mechanically but the operator had to stop and start the machine and the mechanism for this process. This was mechanised as the next stage of development and means of patterning were also introduced, gradually increasing in their scope and complexity.

The invention of the double cylinder machine in 1900 was the major step towards automation. Double-ended needles could be used to knit in either cylinder and transferred from one to the other by automatic selection. This enabled rib and plain knitting to be made on the same machine, so that the entire half hose could be made on the machine without any attention from the operator. The intervening fifty years have seen the addition of patterning systems, which have now become so complex that they can make the entire sock, including insertion of rubber thread to form a garter band, a choice of seven colours for horizontal striping, combination with vertical wrap striping in colour and, more recently, pattern stitch effects also.

The one process which has so far defied automation is that of closing the toe, which is still done by linking. This involves the threading of selected loops in pairs on to a set of points, followed by chain stitching, and it is a skilled trade. The use of ordinary seaming and various heat sealings of thermoplastic yarns have all proved valueless.

It is interesting to note that in both the types of manufacture described, the high degree of automation has only been achieved by modifying the shape of the garment somewhat from the shape and form in which it was produced by hand. The round heel of the fully fashioned stocking is criticised as being inferior in shape to the older heel shapes of the traditional English and French feet. The modern sock has less stretch and elasticity, particularly in the welt, than its hand-knitted counterpart. These facts can be usefully set in balance by looking at corresponding production figures which are average estimates based on the output of one operative in a week of 45 to 48 hours.

	Plain dz. prs.	*Fancy* dz. prs.
Hand knitting on pins (estimated)	½	¼
Hand-operated knitting machine	5	2½
Made on old system of two machines under modern conditions	90	45
Made on double cylinder machine	160	110

These figures provide a striking example of the way in which automation can and, indeed, must increase productivity.

Besides the two particular sets of development which have been presented to you as illustrations of a type of automation, the knitting industry can offer many other examples.

Our previous speaker has indicated that it is not sufficient to build automatic machines which will work on their own.

Importance of Inspection

A rigid and continuous inspection system must be set up to avoid the making of a succession of faulty goods if a machine goes out of adjustment or its raw materials prove unsatisfactory.

It has been the custom for over half a century to fit a variety of stop motions to knitting machines, and they obviously fall in the class of continuous inspection systems. Each yarn on a multi-feed knitting machine passes over a trigger device, through a tensioning system and between a pair of closely set plates. A

thick spot in the yarn will catch in the plates and break, a weak place will be broken by the applied tension. The broken yarn releases the trigger and stops the machine before the end of the yarn reaches the needles. Thus the yarn is continuously examined before it is allowed to be knitted. Other detectors are fitted which react to a hole in the fabric or to a broken needle. In each case the machine is automatically stopped, to be inspected by the operator, who then assumes the role of supervisor and of maintaining supplies to his machine. The devices used are operated mechanically or electromagnetically or by some combination of both.

The warp knitting trade has developed the use of the traversing photo cell which scans the fabric for damages and stops the machine electronically should a fault develop. On its more recent high-speed machines, where the rate of use of warp is very rapid, new let-off motions have been devised which are driven positively through variable speed gears, the ratios being automatically increased as the warp empties and its circumference becomes less. This entirely relieves the operator of the duty of constantly watching and adjusting warp tensions and enables his time to be more usefully deployed.

In conclusion, I hope that these examples will help to convince you that the knitting trade has been very forward in its development of automation.

The labour troubles which the motor industry is now experiencing surely had their textile counterpart in the Luddite riots more than a century ago. Since then, our development has been far more peaceful.

AUTOMATION IN THE DROP FORGING INDUSTRY

by H. M. H. FOX, M.I.Mech.E.,

Works Director, Smith Clayton Forge Ltd., Lincoln.

IN the first place let me say that, although I have been asked to speak to you on behalf of the Lincoln Section on the trends and effects of automation on the drop forging industry, I do not by any means claim to be expert or widely experienced in this particular field, and I am quite certain that any remarks I pass to-day will be quite out-dated within a very few years.

In general, our business is of a very repetitive nature, which lends itself, and indeed is a pre-requisite to the use of automatic means of production, but even so, the quantities of forgings which we are called upon to produce in most cases hardly appears at the moment to justify the very heavy outlay necessary to install fully automatic equipment. It may well be that the users of drop forging may be able so to expand their markets that their demands will be much increased and become large enough to justify automation on economic grounds, but I think it more likely that, in general, we shall have to continue to develop and more highly mechanise, systems at present in use, than be able to effect a complete changeover in the near future to automation.

No doubt you are all familiar with the processes which go into the making of die or drop forgings, such as cutting off, heating, forging, trimming and so on, and I propose to deal briefly with automatic processes as applied, or as could be applied, to forgings of medium weight, taking for example, crankshafts for the automotive industry. Material is bought out in the form of square bars or billets, the first operation being to sever to the lengths required for each forging. This is done by cold saw or cold shear, and feed mechanisms are being developed which permit this to be performed automatically, the only snag to continuous operation being the necessity of bars being supplied to an accurate length to divide exactly into any given number of pieces. As the potential production rate from a shear is higher than could be achieved at the moment by a single forging unit, it seems unlikely that there will be any immediate development for feeding the cut pieces directly into the heating furnace, but it may be that a lower rate of delivery of cut pieces would be accepted in order to combine these stages into a continuous operation.

Heating Arrangements

Dealing now with the heating arrangements, we have the alternatives of furnaces heated by gas, oil or high frequency electricity, commonly known as induction heating. Whichever is employed, charge and discharge can be arranged at a set rate from units

having automatic temperature control. If any preforming is necessary prior to presenting the piece to the dies, it can be passed on a conveyor through a forging roll, a type of machine which is largely taking the place of the forging hammer for this kind of work.

At this stage a choice has to be made between die forging on the traditional drop hammer or a vertical forging press. Although hammers greatly outnumber presses at the present time, it is probable that the latter will ultimately provide the means of automating the actual operations, due to the possibility of synchronising the feed and transfer mechanism with the strokes of the press. Here we can assume that some form of photo-electric cells will provide safety factors by preventing the press from operating if the piece is not properly heated, or is misplaced in the dies, and it also seems a possibility that some form of strain gauge will do the same if for any reason the machine is persistently over-loaded.

Transfer mechanism takes the pieces to the trimming press where the flash is removed, and the forgings are coined into finishing or sizing dies.

Other Kinds of Forging

At this point I propose to talk about two other kinds of forgings, and to show how they are, or can be, produced automatically on other types of equipment. Spindles or shafts as illustrated in Fig. 1 can be produced on a swaging machine (Fig. 2) quite automatically at the touch of a button, the operator having only to load and unload the machine.

Diameters and lengths are controlled by cams and stops, the work being done on a heated and rotating work piece by three eccentrically driven hammers, (Fig. 3) and Fig. 4 shows the work cycle and sequence of operation.

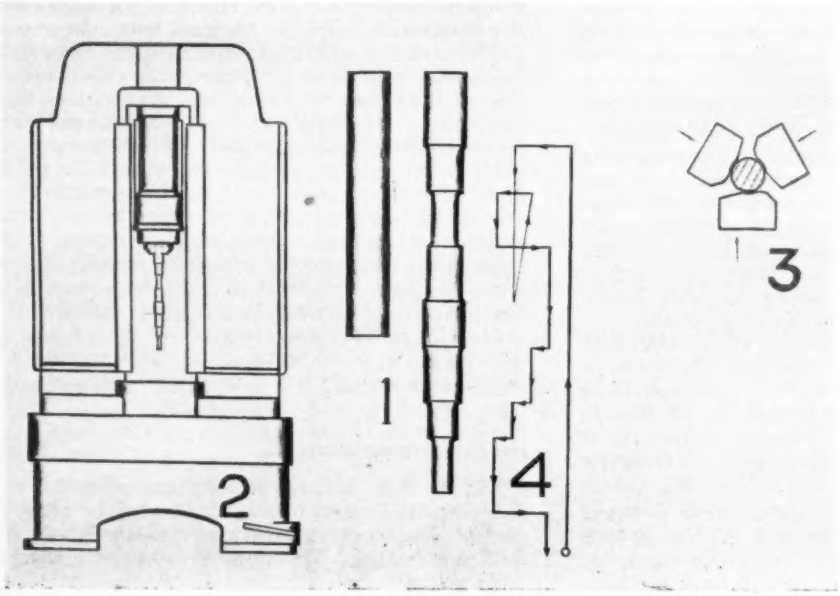
Upset forgings of the type illustrated in Fig. 5 can be produced automatically on horizontal forging machines with transfer mechanism to carry the work piece through the several stages, and this type of unit can be used in conjunction with the swaging machine to produce heads or flanges on pieces previously swaged.

Heat Treatment

Coming to heat treatment, it is usual nowadays for temperatures of furnaces to be electrically controlled, but few completely automatic plants are in use. One such unit, however, is illustrated in Fig. 6, which is used for the hardening and tempering of forgings, and has the advantage of great flexibility, being suitable for a wide variety of work.

The work pieces are placed on trays which are arranged to form a continuous conveyor at the loading and unloading stations, and are moved one by one by traverse car to the hardening furnace. As each tray enters the heating chamber, one at the opposite end descends into a central quench tank where the work is hardened. The trays are then traversed along the bottom of the tank, and raised into line with the input end of the second or tempering furnace, and from there, they are discharged into another traverse car, which brings each tray into line with the original conveyor, which acts as a cooling rack whilst the work is progressing to the unloading station. All doors and mechanisms are controlled by a sequence timer, which permits a feed rate of from one to fifteen trays per hour, the normal being about ten. Following heat treatment, descaling can be carried out by pickling or shot blasting, it being possible to arrange either, on a continuous and automatic cycle.

I think enough has been said to show that con-



Figs. 1 - 4.

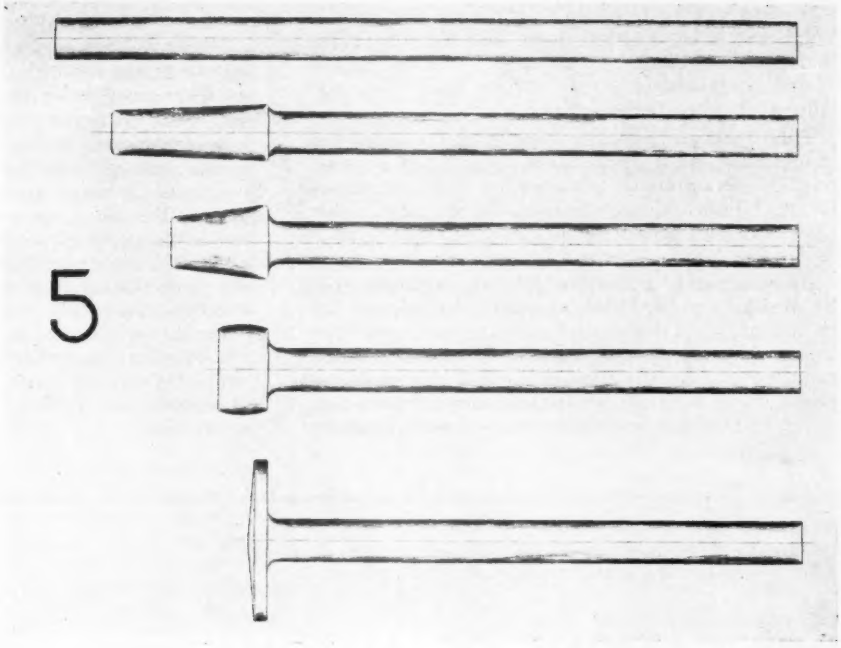
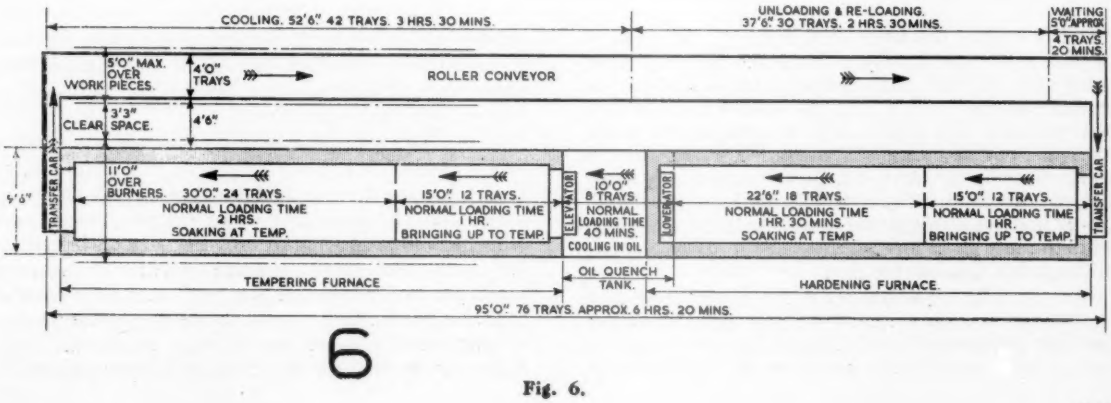


Fig. 5.

siderable progress is being made in an industry in which men have to work extremely hard in conditions of considerable heat, and where the benefit of automation should be most appreciated by the manual worker. Equally, it is under adverse conditions that the performance of the operator falls away both in quality and quantity as the shift progresses, and the benefit of automation should be most advantageous to the company employing it. However, we shall have to rely to a considerable extent on the manufacture of drop forging equipment, and in consequence, it is my opinion that for the next few years, improvements are likely to come from the increased use of linking devices and mechanisms designed to assist the hammer or press operators, and perhaps reduce their numbers rather than completely displace them. The object at all times is to obtain, by these means, a much higher degree of machine utilisation.

One of the major problems will be the excessive heating and rapid wear of dies and tools and a considerable amount of research and development will be necessary in this field if frequent stoppages are to be avoided. When working with hot metal, stoppages and delays often result in spoilt material.

Speaking of dies and tools, I think we may expect considerable improvement in specialised die making equipment during the next few years, especially with the possibility of milling machines working from


COOLING. 52'6" 42 TRAYS. 3 HRS. 30 MINS.
UNLOADING & RE-LOADING. 37'6" 30 TRAYS. 2 HRS. 30 MINS.
WAITING 5'0" APPROX. 4 TRAYS 20 MINS.
WORK
5'0" MAX. OVER PIECES.
4'0" TRAYS
ROLLER CONVEYOR
CLEAR
3'3" SPACE.
4'6"
5'6"
TRANSFER CAR
11'0" OVER BURNERS.
30'0" 24 TRAYS.
NORMAL LOADING TIME 2 HRS. SOAKING AT TEMP.
15'0" 12 TRAYS.
NORMAL LOADING TIME 1 HR. BRINGING UP TO TEMP.
ELEVATOR
10'0" 8 TRAYS.
NORMAL LOADING TIME 40 MINS. COOLING IN OIL
LOWERATOR
22'6" 18 TRAYS.
NORMAL LOADING TIME 1 HR. 30 MINS. SOAKING AT TEMP.
15'0" 12 TRAYS.
NORMAL LOADING TIME 1 HR. BRINGING UP TO TEMP.
TRANSFER CAR
TEMPERING FURNACE
OIL QUENCH TANK.
HARDENING FURNACE.
95'0" 76 TRAYS. APPROX. 6 HRS. 20 MINS.

6

Fig. 6.

punched cards resulting from the use of the operator. Obviously, die-making capacity will have to be expanded to keep in phase with the requirements of highly mechanised forged shops, and fully automatic machines will enable us to make better use of our limited numbers of highly skilled operatives, and employ them to better purpose.

I have not attempted to theorise on the benefits of automation, but it seems to me that, at the moment, most of the automatic processes are being developed for machinists and assemblers of end products, rather than for the producers of raw or semi-finished materials.

As increased quantities of these materials may not be available to feed the automatic factories at the right time, I feel the cart is before the horse, and that we should tackle first things first. We are constantly exhorted to take the men into our confidence, but please let us have proper consultation between ourselves, so that our intentions, made known to those who serve us, will encourage proper long-term planning, so avoiding chaos and the consequent danger of under-employment.

We have been engaged for many years on gearing up our production rates, but please let us make sure we have created the capacity to keep our pipe lines full before attempting to engage over drive.

In conclusion, and in general, as a manufacturing nation we have, over the years, been overtaken, if not surpassed, by other great and rival countries, partly due to the fact that we have tolerated too many restrictive practices, and partly due to the fact that we have been satisfied to achieve targets set well below our true capabilities and capacity. We cannot attempt to stand still or stay as we are, otherwise our position, with respect to other nations, will worsen: it is, therefore, up to each and every one of us to raise our sights and seize with both hands the opportunity to restore our position by increased adoption of automation.

IMPLICATIONS OF AUTOMATION

Part I by H. L. BARMAN, M.A., M.I.I.A.,

Personal Assistant to the Chairman, Rolls-Royce Ltd.

Part II by A. G. CLARK, M.I.Prod.E.

Manager, Technical Audits, Rolls-Royce Ltd.

PART I

THIS subject has been very much in the news of late. We can hardly pick up the paper without somebody, as Wilfred Pickles says, "having a go" on automation, so much so that the word is being abused and misused. Mr. Clark, who is saying a few words after me, will elaborate this to you. Let us make one thing clear for a start; it is going to be many years before automation affects the average business. Don't forget that the average business is small and it is going to be some time before automation, in its true sense, will touch a firm of this kind.

I don't doubt that the smaller firm will introduce automatic machines reading direct from drawings through computers, but I regard this development as only a step beyond the purchase of a common or garden automatic with its cams and what-have-you. It is not until one gets feed-back information that alters and adjusts previous operations, that one is getting into real automation.

If it is going to be a long time before the smaller firm is touched, it is going to be some time before automation has an effect on the human being. We know the motor-car, chemical and radio manufacturers, and other people producing in quantity, are all introducing more and more complex systems of transfer machines, linked together and controlled by a central computer, and this is bound to mean a reorientation of employees' jobs. I am fully in agreement with those who say that the result will be a higher standard

of living, but I don't propose to enter into the politics and express an opinion as to how this rearrangement of jobs is to be carried out.

There is a neat comment on this in this week's "New Yorker"; a picture shows a large factory with a mass of machines all working by themselves, except for one around which there is a crowd of workmen with pieces spread all over the floor, and more workmen hurrying up with their tool kits. The boss is talking to the manager and saying: "Gee, this automation does create a lot of new jobs." How right! NEW jobs, higher skill, more pay and perhaps more leisure. I say *perhaps more leisure* on purpose; 90 per cent. of people don't know how to use their spare time and to give them more leisure simply means more unproductive time being spent on keeping them amused—perhaps by more automation on merry-go-rounds!

The Future of the Smaller Firm

There is a question here that I think requires an answer. As more large firms go all "automative", what will happen to the smaller firm in the same trade? Will they be squeezed out by the bigger firms producing at lower costs, or will they manage to survive? It is here that I think all these firms that are plunging into expensive machinery (and don't forget that automation is very expensive, tying up a great deal of capital), forget that there is such a thing as a purchaser and that he has tastes.

It is all very well to turn out thousands of articles all alike, or all with a comparatively few variations, but there is a limit to what the average man will stand. While the average man will follow-my-leader and buy something that the Jones's have next door, he likes it to be individual so that it can be admired by his neighbours. The public reaction to this can be seen at the present moment in America, where the motor-car manufacturers are having a very serious setback. This is partly due to the average man waiting for next season's models, as he has been told that they are going to be fundamentally different from the present models, and in America he likes being up-to-date.

Now I think, in this field, there is a place for the smaller firm in providing the average man with an article that he wants. They will take the product of an automatic factory and, with their individual ingenuity, tailor it to meet a varying demand.

Look what is being done even in the radio and motor industry; put a new box on to a radio and give it a fancy name, or take a standard engine and chassis, put a body on it and call it "somebody's special". This, I am sure, will still give the individual and the small business a chance unless, of course, everything is nationalised. There is nothing so soul-destroying as the monopoly of a nationalised industry, who are expert at forcing a sub-standard product down the throats of an unwilling public.

Turning to a point that I have already mentioned—the cost of installing highly automatic machines—only the wealthy firms can, at the moment, afford machines of this type. We are sometimes shocked at the high cost of some of the machines that we have to buy, and we have specially to consider the utilisation times of these machines.

The tendency that some managements have to cost their products on an overall basis, as a percentage of labour, will have to disappear, and the management will have to think again. If there is no labour to carry the percentage, more reliance will have to be placed on costing, by either machine hour rate, or directly on to the materials in the products. I will leave the development of this theme to the Institute of Cost and Works Accountants. Finally, however, the medium or smaller firms will have to be putting aside money now to meet the costs of the new techniques that are emerging.

One aspect where, I think, the electronic aids (I prefer these words to automation) will affect the small firm and its management, in the near future, is the introduction of the electronic data processing machine. This is going to change the outlook of the production engineer and shop management in not only deciding what to make and when to make it, but also giving them a control of what is going on. At the moment, only the larger firms can afford the true data processing machines, but development is proceeding so rapidly that cheaper machines, capable of carrying out analysis work, will become possible for the smaller company.

The receipt of an order from a customer usually calls for an analysis of some sort. Are materials available—if not, order them! When are they required? Are tools available? Is machine shop capacity available, and if so, *when* will it be available?

Computers help you to plan this kind of thing and they are capable of assisting, step by step, in informing you if the plan is not being carried out. It is essential, in using data processing machines of this sort, to avoid turning out masses of figures. "Controlled by exception" is the watchword of the computer manufacturers and this enables all the available resources to be put into clearing the exception and keeping the plant running at optimum capacity.

In the firm for which I work we are fortunate in having a need for scientific calculating so we already have a powerful data processing machine, on which we are able to carry out trial runs on office routines. We are examining, in some detail, the introduction of material control utilisation and, at the same time, working in the costing. We can already see that the machines are going to have a profound effect on these functions.

A Long Term Programme

We have, however, learnt that it is going to take much longer than we anticipated and that there is not going to be any immediate saving in staff. In fact, I am optimistic enough to say that, in the long run the number of people we shall employ on clerical functions will probably be the same as we now employ, but they will be doing different jobs, which will have all the drudgery taken out of them. This means a re-training programme and, as I said before, we have much more time to do this than we originally envisaged.

PART II

ONCE again we are attending another meeting dedicated to that well-worn subject: "Automation". My own feelings are that this subject has already received much publicity and not always the best. Whilst a gathering such as this can appreciate that there is nothing sinister about automation and it is only logical for production, it must be admitted that automation is seen as a monster by most people, ready to swallow up their objectives in its massive steel jaws. We read in the newspapers and periodicals more and more accounts of further spectacular possibilities of automation. Whilst these accounts are logical, it is obvious that the strong light of publicity directed on to automation has cast a large shadow before it.

To many people, although automation does not appear sinister, it does appear rather ominous. I think that the very word "automation" was badly chosen. Perhaps "link mechanism" might have met the bill and not caused so much stir. It has been blamed for practically any form of labour redundancy and if such a situation is allowed to develop, the workers will become suspicious of any changes or introduction of new methods. This aspect of automation is perhaps the biggest problem that management will have to face in the future and one which will need the greatest care in planning labour employment during the present period.

To me it is surprising why automation has caused such a stir, because there is nothing new about automation—the only thing that is new is the word. As long ago as 1939 I was personally responsible for starting up a continuous roll mill at Derby for the manufacture of steel strip and bars. The material is heated in a furnace and passed through a chain of some ten reducing rollers and through to the shops, 20-30 miles per hour, where it is cut into customers' lengths. Whilst this is by no means a complete example of automation, it is a process where a steel bar has been formed into a finished section by a mechanically operated mill.

Management Implications

Regarding the implications of automation to management, I do not believe automation will present any entirely new problems that do not exist at the present time, but existing problems will be enlarged and will leave little scope for muddling through. It would appear that management will have to be more thankful, more co-operative and will have to function as a well-balanced team.

A Logical Outcome

On the social effects, obviously these effects will be felt in proportion to the skill and the rapidity of its introduction. If a large number of factories were to become completely automatic overnight, things would be chaotic. However, such a state of affairs is quite impossible and any change will be at such a rate as to allow time, but not too much time, for the necessary social adjustment. As I have said, automation is the logical outcome of flow production. It would appear that the many branched tree of mechanisation, which has grown steadily since the Industrial Revolution, will not suddenly start sprouting branches in all directions because someone has thought of the word "automation".

Another obvious reason why automation cannot suddenly arrive overnight is because there is not sufficient manufacturing capacity, at any rate in this country, to produce automatic equipment in anything like the necessary bulk quantities. This can be well understood by many of you, when you know that the present delivery of machine tools is two years or more.

Regarding the number one question of whether or not automation will bring unemployment in its train, I will make the one obvious point. To have mass production you must have mass consumption, and to have mass consumption you must have full employment. It is of no advantage to the shareholders, management and operators to have a factory of machines capable of maximum output with minimum human effort, when no one has the money to buy these products. This point is perhaps best illustrated by an American trade union official's remarks to the Secretary of the Ford Motor Company. During the American's visit to the factory, the executive pointed to some very large and complicated machines which carried out operations with very little human attention and remarked: "None of these machines pay you any trade union fees." To which the trade union official replied: "And I do not expect any of them buy Ford cars."

During the past century working hours have shortened and the general standard of living has improved and in my opinion, automation will continue this trend. We may look forward to shorter hours, perhaps a 30-hour week, with more time for leisure to be enjoyed by the workers and, I sincerely hope, the management as well.

EDUCATION FOR AUTOMATION

Part I by Dr. H. L. HASLEGRAVE, Wh.Ex., M.A., M.Sc., M.I.Mech.E., M.I.E.E.,

Principal, Loughborough Technical College.

Part II by J. FRANCE, M.I.Prod.E.,

Head of the Industrial Engineering Department, Loughborough Technical College.

PART I

IN my remarks I will use the term "education" to include the training and development that is given in industry as well as the part given in educational institutions, or through lectures and reading of papers, and "automation" to denote the performing of actions by means of machines.

Although the application on a large scale of automation to all spheres of industry, business, commerce and general life, will not come about for very many years, some applications have been with us for 50 years. Many extensions of these applications on a large scale have already been made in recent years and the rate of extension is likely to increase.

The very young, and the future generations, will grow into the automation age and their education represents a problem for long-term planning. A different problem, and one which requires solving quickly, is that of educating the present working community and those who will enter it during the next few years. It is this problem with which I propose to deal—many of the actions taken to solve it will apply to the long term problem.

At the risk of undue simplification, I would divide people concerned with automation, for whom particular needs of education will arise, into the following:—

1. The community in general.
2. Those engaged on operation and maintenance.
3. Those engaged on planning of automation.
4. Those engaged on the designing of means of automation.

1. Education of Community

It is necessary to dispel two false impressions that are prevalent:—

(a) That automation is something new, is coming upon us quickly, and is going to revolutionise living.

(b) That automation will take work away from everyone.

(a) The community must be made to realise that the transference of motions to machines, without immediate human intervention, has been in existence in some form for very many years, and that extension of automation is part of both natural and worldly evolution: "natural" because it is not in accordance with the true dignity of man that his work should be of a manual, routine type that does not require the use to some extent of his brain and his soul. Such work should be carried out by animals, or things without brain or soul. "Worldly" because our desires for material things have passed beyond the possibility of being satisfied by using our human labour very much as animal labour in conjunction with existing machines. The extension of our knowledge of natural laws of science has made possible extension of electrical and mechanical means of performing actions. These means must be fully utilised if we are to satisfy our worldly desires for more material things and more leisure.

May I digress by emphasising that here is the crucial question underlying our present discussions. If, as a community, we are content to have fewer material things and live a simpler life, we can ignore automation and its use by other nations. If we wish to increase our material things, or even retain our present standards, we must develop automation at a rate according to our desires. Having made this latter decision, we must be prepared to face all the social upheaval likely to result in some parts of our country, endeavour to minimise this and spread the hardships over the whole community. Should the whole issue be put fairly and squarely before the people or should they be led into the automation age gradually and through some hardship? I prefer the former action.

(b) It is equally important to get the community to appreciate that automation will not make less work, in volume, for everyone, but should mean everyone doing much more effective work than in the past, and, for some, occupying less time on their work. Many will have to work harder in that their work will call for the exercise of more of their faculties, more brain and soul, than in the past.

These two main aspects must be put to the people in every possible way, by reference in Press articles,

publications, and at conferences, in order to obtain a suitable climate for the extension of automation. I am not in agreement with many who advocate that we must now make large scale plans to educate people for leisure. Perhaps time available for leisure will be increased for the majority of the working community, but I suggest that if automation does call for the exercise of brain by all workers, their minds will turn to using this ability that was previously allowed to rust, and they will naturally need to exercise their brains in their leisure. Means for this exist in many forms already, far from fully utilised, and capable of extension. Would it not be somewhat ironical to develop automation because it uses more of the human brain and provide mechanised amusement to dull the human brain in leisure periods?

2. **Personnel engaged in Operation and Maintenance**

The ultimate aim in automation is to carry out by machines all actions that do not require the exercise of the judgment and control that only the human brain can achieve. The extent to which the aim can be achieved is conditioned very much by economics, but in the ultimate the human being will be at work solely because he uses his brain. He will function by recognising and acting upon certain signs, detected through his senses. He will have to be made aware of the meanings of the signs and of the action that he must take when one, or certain combinations of several, are apparent. He will therefore need to exercise certain initiative.

Maintenance is likely to be planned to involve replacing a unit that is faulty. So the maintenance man will have to know how to detect which is faulty. Periodical checks will have to be applied in certain processes to ensure that action is taken when everything is not correct.

The operations and maintenance men therefore will need to be trained to recognise certain signs and how to act on them; how thus to combine several of their senses and exercise initiative. Training will be essential, and there will be need to retrain personnel for other tasks resulting either from extension of automation or from alteration of products. This training would be carried out in industry. There must be developed both methods of training quickly, and methods of ensuring that workers have the right attitude to training and are willing to be trained. Here is a field for joint action by education and industry to develop the best methods—it is also a field of employment of additional workers as trainers.

3. **Personnel Engaged in Planning of Automation**

Planning of automation involves, first, Work Study and the right use of electrical, mechanical and similar means of operating. The mind must be trained to analyse critically various processes, to realise the possibilities inherent in the available means of operation, to appreciate when it is necessary to alter the design of a machine, such as machine tools, knitting machines or other conventional machines, in order to use certain methods of control. A very sound knowledge of mechanical principles and properties of materials, as well as of electrics, will be needed. All who are in charge of planning must have their minds attuned to the possibilities, and to financial considerations.

There are thus needed specialist courses for personnel in industry in Work Study and in uses of automatic devices. Courses in the latter field will need to commence with refresher instruction in Mechanics and Electrics, and lead to analysis of existing examples of automation.

The present basic courses in engineering—full-time or part-time—should include strengthened study of mechanical and electrical principles, and more emphasis on mechanics of parts and the production aspects than on the theoretical principles of technical features. We need to apply critical analysis to our methods of instruction in order to instil into students the necessary knowledge of principles, the appreciation of the problem of applications and to develop a flexible and resourceful attitude of mind.

4. **Those Engaged on the Designing of Means of Automation**

There are needed electrical engineers with good knowledge of Mechanics, and mechanical engineers with good knowledge of Electrics. These requirements apply to many aspects other than the designing of means of automation, and alterations in our basic courses are not needed only for automation. Some specialist training will have to be given to well-trained engineers after they have embarked upon this aspect of the profession. Their aim is to apply known principles in order to obtain small precise movements of definite extent, resulting from certain impulses or signs. They should become aware of the many possibilities available—chemical, optical, electrical, mechanical, etc.—and so their specialist training should extend their knowledge of principles in all fields of science—wider fields than are covered in the basic course.

Thus, to summarise:—

Community. Educate through press, films, speeches, articles that—

(a) The issue is automation or lower living standards.
(b) Automation is a natural evolution to use brain and human faculties not possessed by animals.
(c) Automation will make more demands upon individuals and in the ultimate there will not be enough human beings to achieve what the community desire.
(d) Automation will call for more planning—with a different aim—more training and more supervision.

Process Workers and Maintenance Workers:

Trained in the factory by special training courses—basic education may improve their response to training. Must be trained in detection of small ranges of signs and the taking of certain actions on these.

There is need to develop methods of quick training and to secure attitude of mind receptive to training.

Planners of Automation:

Good basic engineering course.

Specialist courses in colleges in conjunction with industry in

(a) Work Study.

(b) Means for automation, including refresher in principles of mechanics and electrics, broad knowledge of principles of science involved, examples of automation and to cultivate awareness of possibilities.

Designers of Instrumentation and Controls:

Good basic engineering course.

Specialist Courses in—

Broad principles of science involved in automatic devices.

Application of Automation.

Problems to be faced.

The Automation Engineer

Up to now I have taken the workers as dealing with certain sections of the whole matter of automation, but there emerges from this a picture of the education needed by the Automation Engineer, who is concerned with the whole field and who will direct and co-ordinate the specialists who deal fully with portions of the field.

He needs first a good basic engineering course containing sound grounding in Mechanics, Electrics, Materials, then specialised training—in stages—sandwiched with industrial experience—to incorporate eight different features:—

(1) Full understanding of purpose and aims of automation.

(2) Knowledge of physiological and psychological traits of human beings—in particular the working of the brain, and its control of the functioning of the limbs as a result of the brain's response to signs detected through the senses.

(3) Broad knowledge of all principles of science used, and possible of use, in automation.

(4) Understanding of principles of existing instruments and control devices used in automation.

(5) Work Study.

(6) Planning in the use of controls and the necessary re-design of machine and process.

(7) Financial aspects.

(8) Statistical and Quality Control aspects.

PART II

WE have heard a lot of talk on the need for education in automation. We have heard a lot about the 'ballyhoo' going on at present, and when we look back that 'ballyhoo' was started at Margate. I suggest that all this is part of the process that Dr. Haslegrave has said is necessary, the education of the general public. What is going on in the Press now is this education of the public, and it is bound to take these fantastic forms. In many cases, it is the only way it will get across to the public. One speaker earlier this afternoon said that every man, woman and child knows something about automation; should we not be glad of this ? It is far better than to have people come along and say that nobody is interested. I suggest that what is going on in the Press now is very valuable, and will in the end help rather than hinder the work of the production engineer in putting his ideas across.

Some of the talk today has been rather general, but two of the Papers we have had have been concerned with technicalities. There was one Paper which dazzled us with the colour of socks ; the other was concerned with drop forgings. We have here today a gathering of people who are probably less influenced by the 'ballyhoo' of automation than any other body. They appreciate what it does mean in reality ; they appreciate its processes. I think it is so very significant that when we had a Paper by Mr. Fox, on "Drop Forgings", the discussion centred on the finer technicalities of production. There was no cross-examination of Mr. Fox on electronics, nothing about feed-back and all the other science we were blinded with ; it came down to much more fundamental things. Now that confirmed to me that in our technical colleges education in the fundamentals of production processes and production techniques has got to go a lot further than it goes today. It will no longer be satisfactory under conditions of automation to rely upon old methods. When a plant costing thousands, and maybe millions of pounds, is to be put down for doing a job, it has to be thought out very carefully in the beginning. The plant has to be built before it is really known whether it is going to do its job and, therefore, it has got to be based on very sound principles. It seems to me that we have got to be a lot more sound in our teaching of the basic principles of engineering production than we are today.

Discussion has also centred on all this time and all this leisure which we are to gain. Do not forget that we have already morgaged quite a lot of it. Time was when a person started work at 10 years of age and worked until he died. He worked from six o'clock in the morning until he fell asleep in the late hours of the evening. Reduction has been going on progressively in the length of working life as well as in the length of the working day. The school leaving age now has risen to 15 years but it is more satisfactory, indeed almost essential, to stay until 18 or 19 years of age the better to be fitted eventually to achieve the higher executive jobs. This absorbs time and it seems to me that a large proportion of the time which automation will save has got to be applied in directions like this : not necessarily in leisure but in fitting the youth of the community for the life that is to follow.

Finally, I would like to say how much I agreed with Mr. Clark in one of his remarks. In the future there will be no place for the method of muddling through. The alternative rests upon the quality of the fundamental training of the production engineer.

TRACER-CONTROLLED PANTOGRAPHIC MILLING*

by A. D. GUNDERSON,

Assistant Chief Engineer-in-Charge of Tooling,

George Gorton Machine Company.

UNUSUAL progress in automation of innumerable machine operations and mechanical assemblies has been made in recent years. Many are developments of past days and no up-to-date tool engineer would take the time to give a second thought to the application of manual controls even for comparatively small-quantity lots. Other quite recent phases of automation are more spectacular because of their newness and complexity.

The shortest route to a given place is the most direct and most heavily travelled. This can only be compared to simplicity and directness of approach in accomplishing a desired goal in a machining operation due to the inventiveness of the tool engineer. Generally, there is a tremendous premium upon simplicity. Probably some of the difficulties find their root in unfamiliarity with standard and semi-standard machines and machining practices in common use to-day.

The tool engineer who has faced rising costs, competition, closer manufacturing tolerances, and more complex machining operations has frequently found the answer in manual tracer-controlled pantographic milling. Now, by extending automation to pantographic milling, exacting high-production profiling work can be done by relatively inexperienced operators. This is true, whether the work piece is flat, uniformly curved, cylindrical, spherical, or irregular in shape, and either two-dimensional areas or three-dimensional solids. In addition, the pantograph can be used to reduce, enlarge, reverse, or invert, either at a 1 : 1 ratio or at any ratio within the limits of the machine.

In the past the pantograph has been known as a small machine capable of engraving and light profiling limited size. This identification has been largely responsible for limited exploration by industry of the possibilities in the use of pantographs in modern-day production. To-day, the pantograph has grown up and has entered the field of removing metal on a production basis with new applications being explored almost daily.

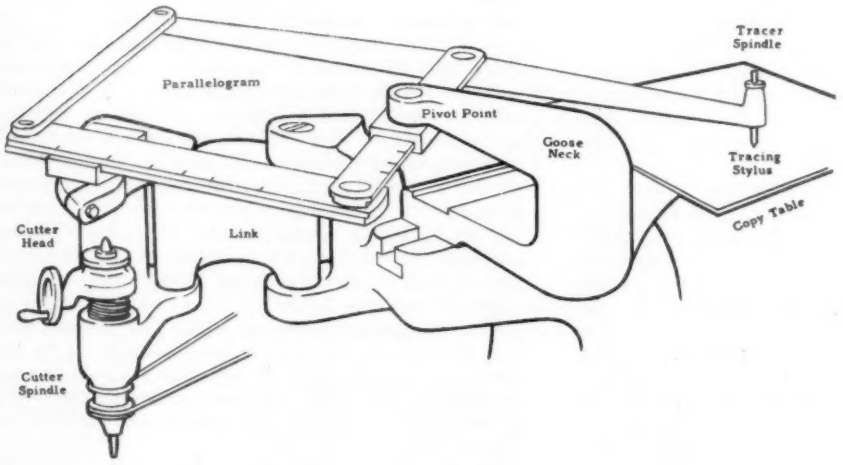


Fig. 1.

Schematic diagram of a pantograph on a machine base fitted to cutter head and link.

* *Presented at the 22nd Annual Meeting of the American Society of Tool Engineers, and reproduced by kind permission of the Society.*

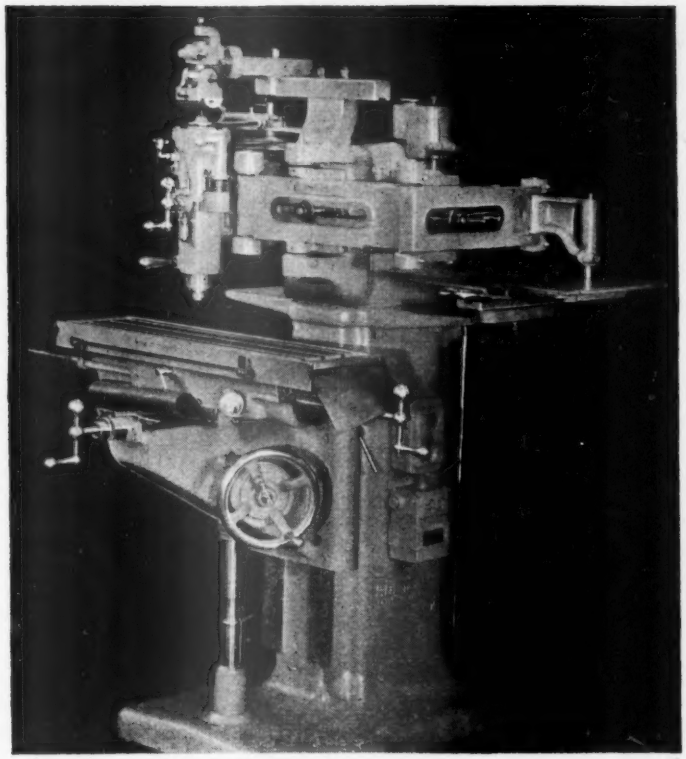


Fig. 2.

Standard two-dimensional pantograph machine.

Definition of a Pantograph

The pantograph machine of to-day may accurately be described as a high-speed vertical spindle machine used to mill or engrave in metal or plastics to precision standards through a reduction ratio. This would seem to parallel the characteristics of a conventional vertical mill. Contrary to these characteristics, however, the pantograph has a movable spindle, fixed work table, and fixed copy table. The work table and copy table can be adjusted laterally and vertically for set-up purposes. Fig. 1 is a diagram of a basic two-dimensional pantograph.

The important variation from conventional machine design is the pantograph mechanism itself. It consists of four bars which form a parallelogram. The reduction ratio, which is a specific characteristic of the pantograph, is made possible by these links.

One of the pantograph bars, or links, is longer than the other three. The tracing stylus is located at the far end of this long bar. Next, the cutter spindle is located immediately under a slider block which is attached to the pantograph link or bar which runs parallel to the long bar. Another slider block is mounted on the bar which is in between the tracing stylus and cutter spindle and which is at right angles to the tracer spindle bar. This second slider block is attached to a fixed support. The tracer spindle, pivot point, and cutter spindle must always be in such a position that a straight line can be drawn through their centres in order to produce true proportioned work.

This definition and description pertains to two-dimensional pantographs. It is necessary to set two slider blocks to correct positions on two pantograph bars to obtain ratios from 1 to 1 to as great as 100 to 1.

Ratios on three-dimensional pantographs are obtained by setting four slider blocks instead of two; however, the ratio is limited to approximately 8 to 1. Fig. 2 shows a standard two-dimensional pantograph machine and Fig. 3 is a standard three-dimensional pantograph.

Variations of Standard Design

Due to the design of standard model pantographs, and the fact that the cutter head is fastened directly to the pantograph link or bar which runs parallel to the long pantograph arm which carries the tracer spindle, it is impossible to incorporate more than one spindle on a given machine. However, special machines have been designed for specific applications incorporating up to six spindles which are belt-driven with spindle speeds up to 18,000 r.p.m. The belt-driven spindles are interchangeable with direct-drive high-speed spindles having an idle speed of 48,000 r.p.m.

It is highly essential that a pantograph machine be rugged enough for the type of work it is called upon

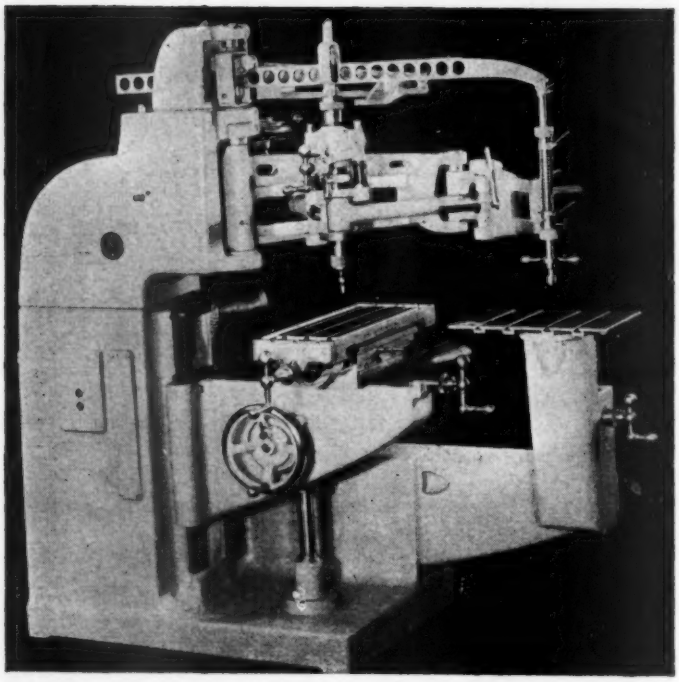


Fig. 3.

Standard three-dimensional pantograph machine.

to do, yet must be accurate and sensitive. Therefore, almost invariably the pantograph is belt-driven, with standard model pantographs having spindle speeds up to 18,000 to 20,000 r.p.m. Special operations which require higher speeds, such as shown in Figs. 4 and 12, can obtain such speeds by substituting a direct-drive spindle with integral motor or one of several standard air spindles. The set-up in Fig. 12 suggests itself for various toolroom applications.

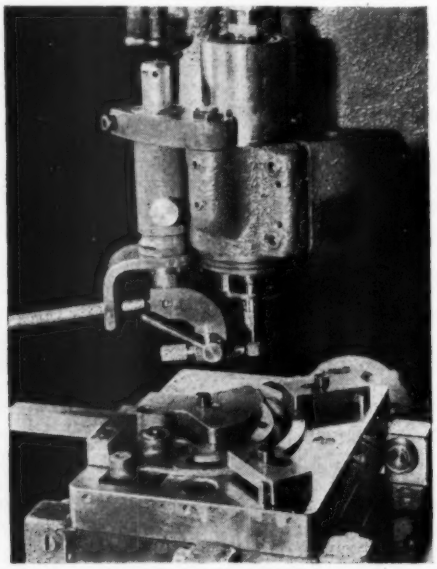


Fig. 4. Pantograph employing air spindle for grinding application.

Electric Etching

Where marking is required on heat-treated parts, the standard belt-driven spindle is replaced by an electric arc etching head. Electric etching offers many advantages with which the tool engineer is usually unfamiliar. Etching does not stress the work, change lines of material flow, or leave sharp corners, all of which would tend to start fatigue fractures in highly stressed aircraft engine parts. Round surfaces, convex or concave, and irregular contours, can be etched as easily as flat work by an untrained operator. The vibrating electrode heads (Fig. 5) are very flexible and lend themselves well to multiple-spindle applications.

Cutter and Stylus Relationship

Pantograph ratios and the relationship between the cutter and tracing stylus appear complicated and yet are comparatively simple when understood. Considering a work piece of 1-in. diameter, and assuming that the ratio of reduction is to be set at 10 to 1 on the machine, the master must then be constructed ten times larger or 10-in. diameter (see Fig. 6). With this true ratio master, it will be necessary to use a tracing stylus ten times the diameter of the cutter. Many times this is impractical because the tracing stylus would become too large for efficient operation. When this is true, another method described by the dotted lines in Fig. 6 is employed. The master is enlarged beyond its original ten-times size and the tracing style is reduced proportionately in diameter, but the

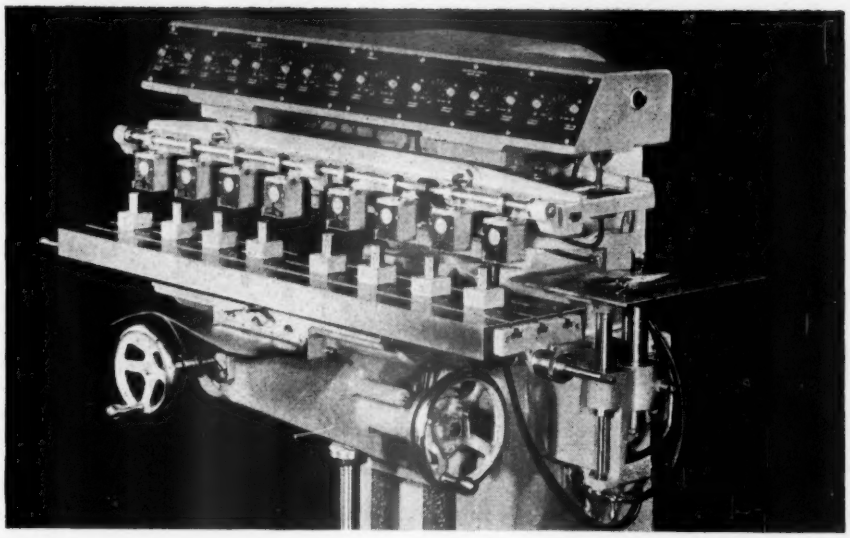


Fig. 5. Pantograph equipped with eight electric arc vibrating electrode heads.

centre-to-centre distance between master and tracer must still remain ten times the centre-to-centre distance between the cutter and work piece. Therefore, using a work piece of 1 in. diameter, a cutter $\frac{1}{4}$ in. diameter, the distance from centre of work piece to the centre of cutter would be $\frac{5}{8}$ in., this in turn would be $6\frac{1}{4}$ in. on a 10 to 1 ratio master. A standard 10 to 1 ratio stylus would be $2\frac{1}{2}$ in. diameter with a true ratio 10 in. diameter master. By increasing the master, as an arbitrary example, to $11\frac{1}{2}$ in. diameter and reducing the tracing stylus to 1 in. diameter, the $6\frac{1}{4}$ in. dimension remains constant and the work piece is profiled to a true dimension. The tracing stylus is often left slightly oversize for roughing or semi-finish cuts; this leaves a small amount of stock on the work piece until the finish cut is taken with a true proportional size stylus.

Low Cost of Operation

Innumerable setups for short-run jobs usually spell grievance for the set-up man or department foreman.

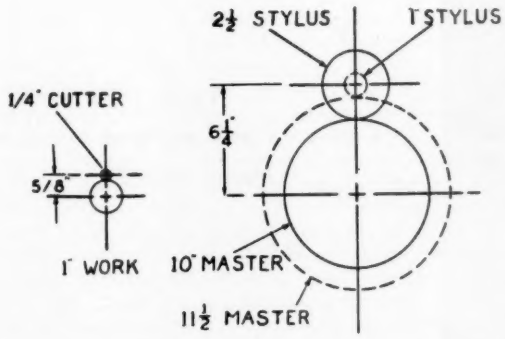


Fig. 6. Diagram showing relationship of cutter to stylus and work to master.

The pantograph has come importantly into its own for short-run set-ups. These are accomplished by constructing simple enlarged masters made of wood, brass, aluminium, plastics, or even cardboard in some cases. These masters may be complete in every detail or merely a segment, to be made flat, curved, or irregular in shape. Inasmuch as they are made several times larger than the finished work piece, tolerances are generally not difficult to maintain. For example, a 0.010 in. error in the master would be reduced to 0.001 in. when the reduction ratio is 10 to 1.

Another technique used to reduce set-up time is to key the work-holding fixture to a tee-slot on the work table, and key the master to a tee-slot on the copy holder so that the angular or parallel location, which ever may be the case, is correct. In addition, set-up holes are incorporated in the fixture and in the master so that the operator may install a tracing stylus into the chuck-nut of the spindle as well as in the tracing stylus position, and move the work-holding fixture, which is mounted on to the machine table by means of the cross and longitudinal feed screws, until the set-up holes on the fixture and master line up in correct position. This is determined when the tracing

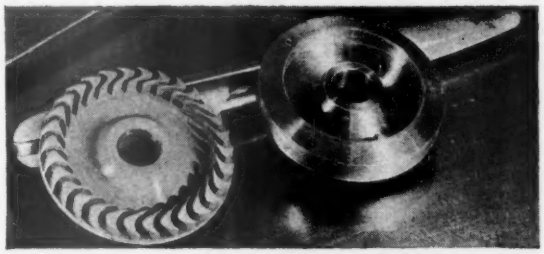


Fig. 7. Blank and finished compressor wheel with 30 buckets automatically profile milled on a pantograph.

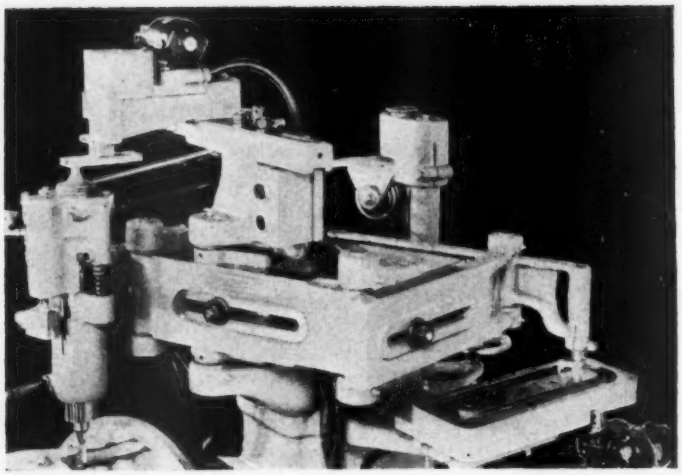


Fig. 8.

A two-dimensional pantograph with special fixture to mill eight ports into the periphery of an aluminium alloy casting.

stylus installed in the cutter spindle for set-up purposes lines up with the work-holding fixture set-up hole, and the tracing stylus located in the tracer arm of the pantograph lines up with the set-up hole in the master. This type of tooling, fixtures, and masters need not be expensive; in many cases may be made from soft steel and/or brass.

Accuracy

Whether for high or low production output, it is equally important to know that a high degree of repetitive accuracy is obtainable. This very important point is characteristic of the pantograph. Once the ratio of reduction has been decided upon, the master has been suitably designed and constructed, the cutter sizes and types determined, the speeds and feeds (when using motorised masters) properly calculated, and the number of roughing and finishing cuts established, every single succeeding work piece coming off the machine, whether ten minutes later or two years later, will be identical to the original work piece.

Because the pantographic method makes it possible for the user to compensate for any existing machine error by intentionally deforming the master, we can say that the pantograph is the only machine that will produce greater accuracy at the cutter point than is fed into the machine at the tracer point.

A standard pantograph built by a reputable manufacturer is capable of providing more accuracy in work for which it is fitted than any other type of machine. In addition, there are many operations in the metalworking field to-day which, because of their shape, size, or inaccessibility, cannot very well be performed on any other machine than a pantograph.

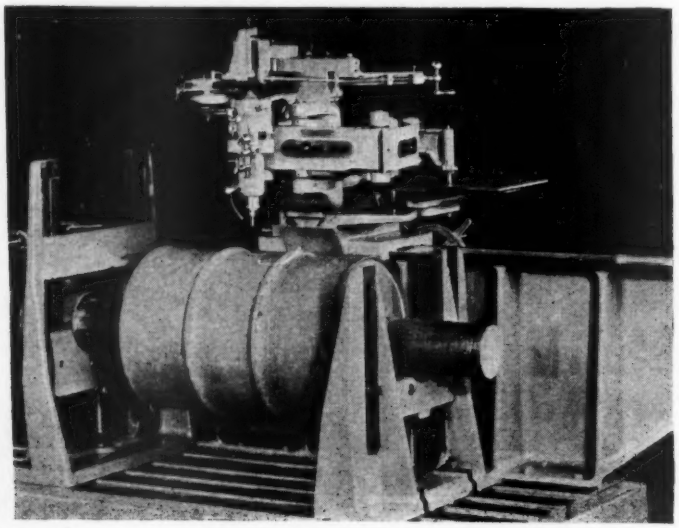


Fig. 9.

A two-dimensional pantograph set up to engrave steel rolls.

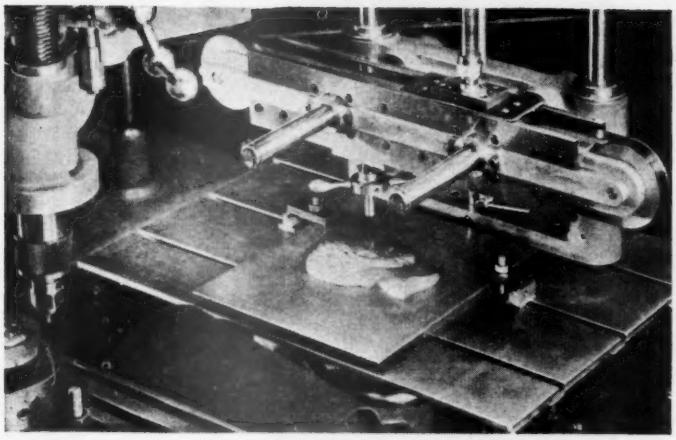


Fig. 10.

A reversing attachment on three-dimensional pantograph.

A reduction ratio is a desirable feature in the tool and die-making field. It can be readily realised that due to the well-known principle of leverage, the operator exerts only one-tenth the effort at a 10 to 1 ratio than would be necessary at a 1 to 1 ratio.

A pantograph is more complicated than many other conventional machine tools and frequently presents seemingly insurmountable problems which have caused a few to acquire a sceptical attitude. Probably some of the difficulties are due to unfamiliarity with the pantograph. Close adherence to the manufacturer's instructions and familiarity with the characteristics of the pantograph have made possible enormous savings in production time and costs wherever it has been diligently put to work. Short runs can be economically handled. In many cases the pantograph can be converted to semi-automatic or completely automatic operations for long runs, with one operator tending several machines at a time.

Deviations to Obtain Automation

Many developments and variations have been made since the conventional pantograph was first built for engraving purposes. Pantographs are now definitely in direct competition on chip removal operations in high-production profile milling operations. This is being accomplished with automatic and semi-automatic features, such as pneumatic and/or hydraulic-operated holding fixtures and controls, motorised masters, various types of scanning devices, cam-controlled cutter feeds, and automatic indexing of work pieces with an electrically controlled stop at the completion of the work piece. These features have been successful along with multiple cutter spindles driven by belt from a single motor or by individual motors. Motorised masters are usually quickly interchangeable with manually traced masters, thereby adding to the versatility of the machine, minimising idle time, and thus making the machine available for short-run profiling and engraving operations which includes innumerable applications.

Range of Application

There is no general size limitation to a pantograph. There are table models weighing from about 30 to 50 pounds and there are pantographs weighing in excess of 10,000 pounds. The scope of work likewise varies widely. A standard model pantograph has been used to engrave the Lord's Prayer of approximately 300 characters within a circle five thousandths of an inch (0.005 in.) in diameter and another standard model has been used to mill the intaglio design in scoring plates, which emboss designs in rug pads of approximately 15 ft. by 15 ft. size. Other models have been used to cut designs on the surface

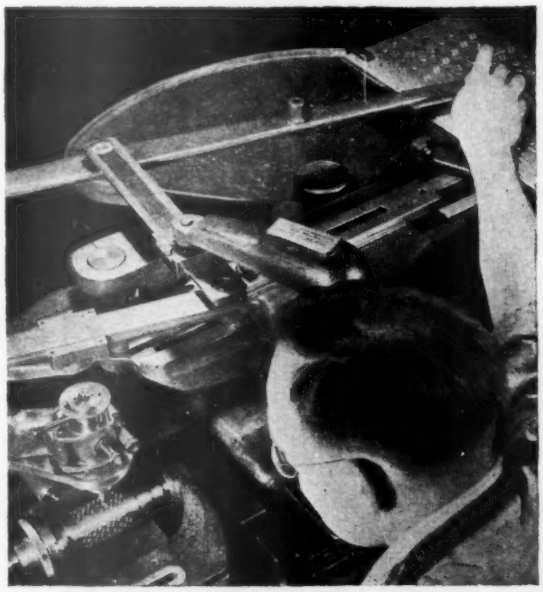


Fig. 11. Continuous roll engraving from a flat master.

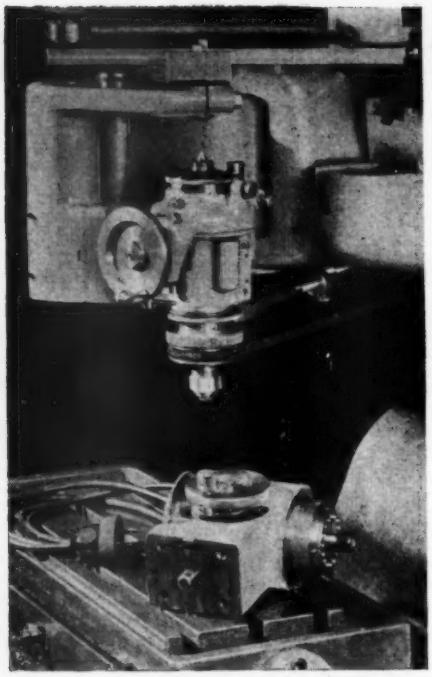


Fig. 12. A belt-driven spindle in machine and an interchangeable electric driven spindle lying on machine table.

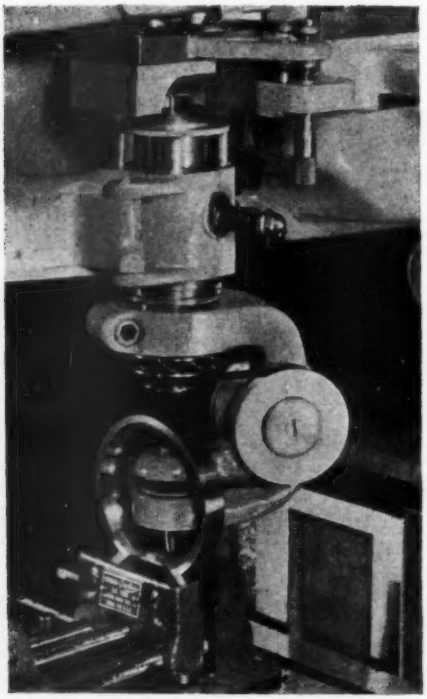


Fig. 13. A special offset spindle.

of rolls and cylinders up to 30 in. diameter by 12 ft. long. Each letter of the Lord's Prayer was 0.0002 in. high and approximately 1/40,000 of an inch deep. Because of this slight depth, the mere rubbing of the finger across the pin point would completely destroy this precision work. Using the same size characters, the entire 3,500,000 characters of the Bible could be engraved within an area $\frac{1}{2}$ in. by $\frac{3}{8}$ in. A pantograph machine was tooled up for automatically profile milling 30 buckets on a small compressor wheel shown in Fig. 7. The operator loaded the piece part on to the automatic indexing work-holding fixture and depressed a start switch which caused the machine to follow through a completely automatic cycle, profile milling all 30 buckets from solid stock, stopping at the completion of the profile milling operation. This particular operation employed a single flute 0.036 in. diameter cutter which was $\frac{7}{32}$ in. long. The floor-to-floor time was approximately 33 minutes.

Versatility

A larger two-dimensional pantograph machine was tooled up to include a special fixture mounted directly to the column ways, a power-driven master, and an automatic downfeed unit. A close view of the operation may be seen in Fig. 8. A special rapid down-feed mechanism was built into the spindle assembly so that the spindle would rapidly approach the cutting operation, after which the power down-feed unit slowly fed the cutter downward during the cutting cycle, while the power master propelled the cutter spindle through the proper path to develop the eight ports which were milled into the periphery of the aluminium alloy casting, to correspond to correct called-for dimensions. Fig. 9 shows a still larger pantograph for engraving identification numbers into the periphery of heat-treated steel rolls with heat treatment specifications up to Rockwell C55.

Mould makers are constantly confronted with the problem of developing right-and left-hand sections to match perfectly, even though dimensional control is not important. A reversing attachment such as shown in Fig. 10 has been used in conjunction with a three-dimensional pantograph to develop both the right- and left-hand sections from a single master.

Standard-model pantographs, or adaptations of them, have been used in such diversified work as alphabet moulds for alphabet soup, breech block and breech rings for heavy artillery pieces, fire interrupter cams for aircraft machine guns, fraternity rings, 18-foot propellers for heavy bombers, table silver, plastic spectacle frames, cookie moulds, and forging dies.

Continuous roll engraving from a flat master is accomplished on a standard pantograph as noted in Fig. 11. The application consisted of engraving "United States Postal Money Order" on a knurl from a flat master. The master was enlarged three times size and was engraved from copy strips of standard master copy type. A standard roll attachment was used to hold the cylindrical work piece between centres where it was rotated synchronously with the longitudinal movement of the tracing stylus. The

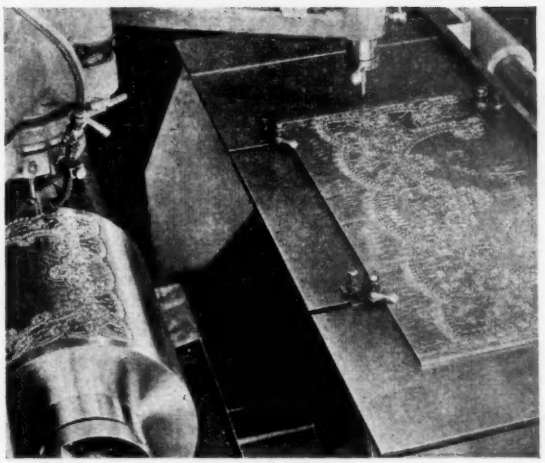


Fig. 14. An example of the intricate designs obtainable.

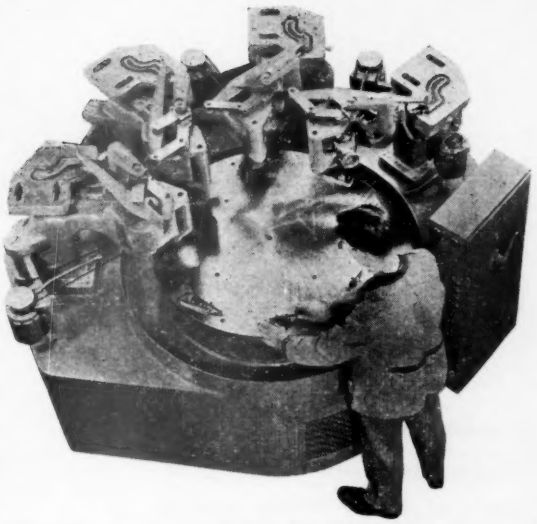


Fig. 15. Transfer type machine with four pantograph mechanisms.

work piece was used to roll in the raised lettering on watermarking rolls for "United States Postal Money Order" paper.

Where advantageous, the standard belt-driven spindle may be interchanged with a high-speed electric spindle, such as seen lying on the machine table in Fig. 12. In this particular case, the pantograph may be used for profile milling and profile grinding.

The versatility of a pantograph can be illustrated by one case, in which the operation was to cut a thermal slot in the trailing edge of an eight-foot aircraft propeller blade tip. The location of the slot was determined by X-ray to fix the position of an internal weld between the edges of the two metal sheets which form this hollow blade. Dimensions were not obtainable from the part drawing or blade. Therefore, the enlarged master was developed with the use of an enlarging spindle on a three-dimensional pantograph, and a pattern was machined out of mahogany. From this pattern, a grade "A" Meehanite casting was obtained and machined true to form with the use of the mahogany pattern itself.

Engraving on the inside diameter of heat-treated valve seat inserts necessitated the use of a special offset spindle and a standard pantograph as noted in Fig. 13. A diamond tool was used to engrave 0.003-in. deep. The contour was followed by the use of a forming guide.

A special-purpose pantograph (Fig. 14) was developed to rotate the work automatically for the milling, embossing, and die cutting of rolls. The work piece, or roll, is held between centres as on a lathe. Movement of the tracer, forward and back, automatically rotates the roll. The operator controls a manual scanning device for heavy roughing cuts. This unit is demountable for manual operation of a

(*concluded on page* 740)

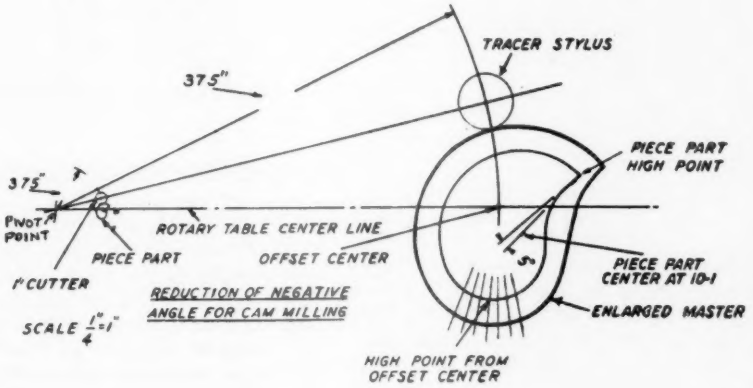


Fig. 16.
The reduction principle of a contour milling machine using the pivoting beam.

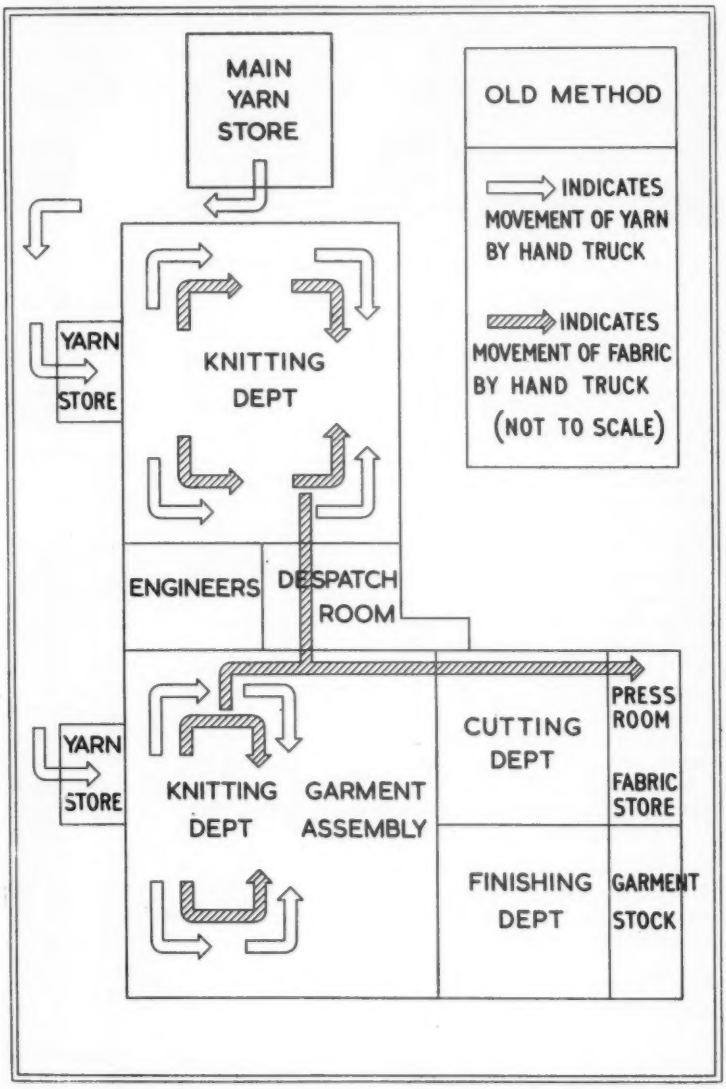
old method

CASE STUDY No. 9

Example of feeding yarn to the Knitting Department at Cooper & Roe, Ltd., Eagle Works, Carlton Road, Nottingham.

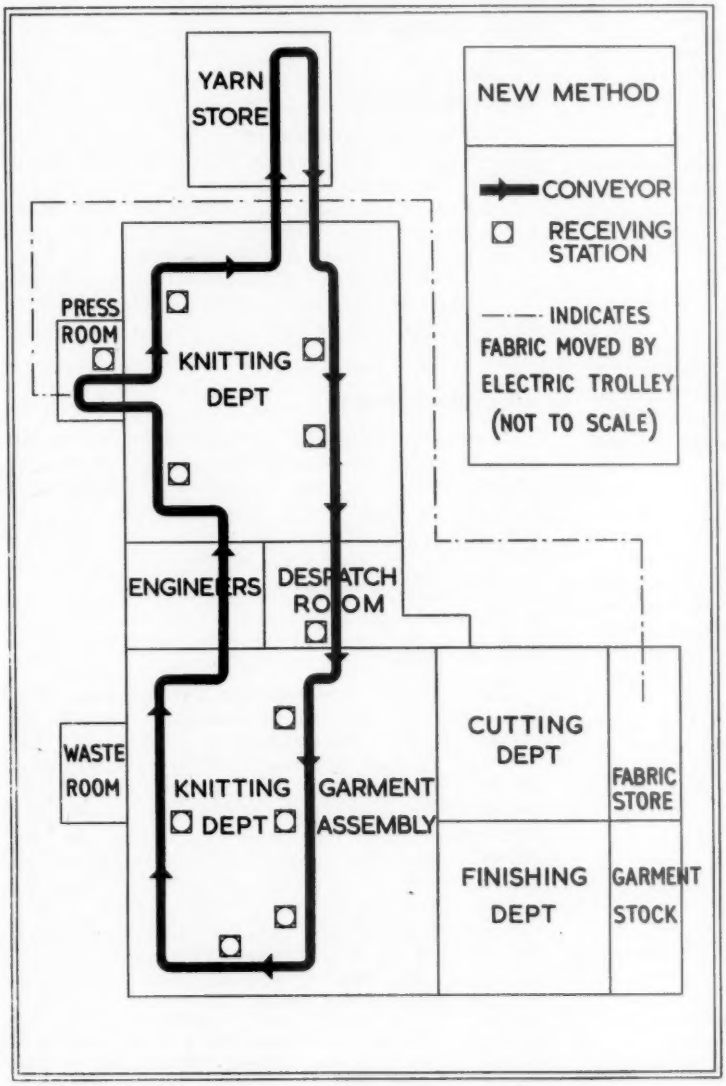
The Company. The company where this example was introduced employs 900 operatives, engaged in the manufacture of underwear and outerwear.

The Problem. To supply two knitting departments with an average of 25,000 lb. nett weight of yarn per week from a yarn store situated outside the main factory block. This yarn is in the best condition for knitting after being allowed to mature for a period of time, as was provided by the yarn store.



Supplying the plant with this material entailed movement by hand truck of cases of yarn, averaging 350 lb. gross weight, from the yarn store directly to the knitting department. Each knitting department used a room (800 sq. ft.) off the main shop as a temporary store for yarn in excess of immediate requirements. Individual knitting machines were supplied with yarn by "yarn boys" or by the "knitters" helping themselves from cases delivered either in the temporary store or near the machines.

new method



A form of mechanical handling was desired, the object being to save labour and to supply the raw material in such a way that yarn stocks in the factory were kept to a minimum. An overhead conveyor was installed encircling the knitting plant and connecting the yarn store. This conveyor was fitted with carriers accommodating fibre trays, each tray have a capacity of 25 lb. of yarn.

A number of automatic receiving stations serviced the knitting departments, and the same number of loading stations were planned throughout the conveyor circuit. Yarn required for immediate production was placed on to the conveyor and delivered to the correct work station by the automatic clock setting on each carrier.

On delivery, the trays were emptied and placed back on the carrier for return to the yarn store.

Cost

The total length of the conveyor is just over 300 yards, and when this was installed in 1947, the cost was £4,500. This conveyor services nearly 500 knitting machines, therefore the cost per machine works out at about £90.

Savings and Advantages

1. Yarn stocks in the knitting departments reduced to a minimum.
2. Floor space released in the factory allowed subsequent installation of extra knitting plant.
3. The two subsiduary yarn stores were released for other uses.
4. Yarn delivered to the correct knitting section at the time required.
5. Release of labour for more skilful tasks.
6. On completion of the installation, the production of the same knitting plant was increased by about 10% through efficient raw material servicing.
7. The conveyor also facilitated the task of removing the fabric, when knitted, from the machines.

REPORT OF THE MEETING OF COUNCIL

Thursday, 25th October, 1956.

THE second Council Meeting of the 1956 - 57 Session was held at 10 Chesterfield Street, London, W.1, on Thursday, 25th July, 1956. The meeting, at which the Chairman of Council, Mr. H. G. Gregory, presided, was attended by 27 members, and the following were present by invitation :-

Mr. W. A. Hannaby, Chairman, Halifax Section; Mr. N. Holmes, Hon. Secretary, Peterborough Section; Mr. E. J. Lownes, Chairman, Wolverhampton Graduate Section.

Election of Vice-Chairman

The Council unanimously adopted the Finance and General Purposes Committee's recommendation that Mr. H. W. Bowen, O.B.E., be elected Vice-Chairman of Council, in place of Mr. A. F. Kelley, who had tendered his resignation because of heavy business commitments.

Finance

The Chairman reported that the audit of the accounts for the financial year ended 30th June, 1956, has been completed and it was hoped to submit the auditors' report and accounts to the Finance and General Purposes Committee meeting in November. It was agreed to follow the practice of recent years, in which the audited accounts are sent to all members of Council for approval, so that they may be presented to the Annual General Meeting in January, 1957.

National Conference, 1957

The Secretary reported that the first meeting of the Organising Committee would take place on 8th November, 1957. The members of the Committee are :-

The Principal Officers	Mr. R. K. Grunau
Mr. G. R. Blakeley	Mr. A. A. Jacobsen
Mr. J. M. Brice	Mr. F. T. Nurrish, M.B.E.
Mr. W. H. Bowman	Mr. G. R. Pryor
Mr. H. Burke	Mr. R. Ratcliffe, M.B.E.
Mr. F. G. S. English	Mr. R. H. S. Turner
Mr. A. A. J. Francis	Mr. J. H. Winskill
Mr. A. Griffiths, O.B.E.	Mr. F. Woodifield

It had already been decided, at the previous Council, that the Conference would take place at Harrogate from 30th June to 3rd July, 1957, and would deal with technological change and the resultant development of control systems.

Education Officer

The Secretary reported that Mr. H. Wyndham Badger left the Institution's service on 31st August, 1956. An advisory committee consisting of the Chairman of Council, the Chairman and Vice-Chairman of the Education, Membership and Research Committees, and the Secretary, had been set up to consider the appointment of a successor. The frequently expressed need for a Technical Officer will be taken into account.

The Annual Dinner

The Secretary reported that over 500 members and guests attended the Annual Dinner at the Dorchester Hotel, London, on 5th October last, which again appeared to be a highly successful and enjoyable occasion. The Minister of Labour and National Service, the Rt. Hon. Iain Macleod, M.P., was the principal guest.

D.S.I.R. Film

The Secretary reported that the Institution had been asked to assist in the making of a film for D.S.I.R. by the Central Office of Information. The film took the form of a case study based on improvements in productivity in his company introduced by an executive as a result of his attendance at a Conference, The case study was a true one, the executive concerned being a member of the Institution and the conference on "Compressed Air" organised by the Cornwall Section at Easter, 1955. With the co-operation of members of the London Graduate Section and of the Library Committee, various sequences for the film have been made at the Institution's Head Office.

Broadening the Base

It was reported that the Education Committee were continuing their discussions on redrafting the examination structure. A special sub-committee on syllabuses was also active. It was hoped that a detailed report, with the recommendations of the Committee, coupled with those of the Membership Committee, would be available for Council during the current Institution year.

Summer School

The Institution's Summer School, which was held at Ashorne Hill from 25th - 29th July, 1956, included a greater representation of educationalists than previous Schools. The theme was "Education for Automation" and the quality of the discussions was very high.

Schofield Travel Scholarship, 1956

The Council recorded with pleasure that the Schofield Travel Scholarship for 1956 has been awarded to Mr. H. Scholes, Graduate, New Products Engineer/Project Engineer, of Joseph Lucas Electrical Ltd., Burnley. Mr. Scholes is the Chairman of the Halifax Graduate Section.

Delft Conference

The Council unanimously accepted the recommendation of the Finance and General Purposes Committee that the report of the Delft Conference of University Professors, organised by the Institution, should be published. It was agreed that it should appear in the Journal (see pages 715/726, this issue) and also as a separate publication with a selected circulation to universities, technical colleges and other bodies concerned with education.

Membership Certificate

Some discussion took place on proposed changes in the size and style of the Institution's membership certificate. Several opinions were expressed and it was finally decided that this matter should be left to the discretion of the President and Chairman of Council to make such changes as were considered necessary.

The Journal

It was reported by the Editorial Committee that a less expensive paper was now being used for both the editorial and advertising sections of the Journal. Experiments were still being made with different types of envelope for despatching the Journal and the comments of members would be welcomed. Some members had stated the opinion that wrappers were preferable to envelopes, but unfortunately in view of the present size of the Journal wrapped copies would not be accepted by the postal authorities.

With regard to publicity, the affairs of the Institution continued to attract a gratifying amount of publicity and it was interesting to note that from time to time the Committee were approached by lay and technical editors for assistance in finding authors to contribute articles on production engineering matters on a very broad range.

Institution Papers

The following report was made by the Papers Committee :-

(a) *The* 1956 *Sir Alfred Herbert Paper* will be presented at the College of Science and Technology, Manchester, on 14th November, 1956, by Dr. B. V. Bowden, on the subject of "The Development of Technological Education in Europe, America and England". The chair will be occupied by the Chairman of Council, Mr. H. G. Gregory.

(b) *The* 1956 *Viscount Nuffield Paper* was presented at the University of Bristol on 17th October, 1956, by Dr. W. Grey Walter, of the Burden Neurological Institute, who spoke on "Thinking Machines". This was a most successful meeting and attracted a capacity audience. Sir Walter Puckey, Past President, was in the chair.

(c) *The* 1956 *George Bray Memorial Lecture* will be presented in Sheffield on 18th March, 1957, by Mr. Stafford Beer, Production Controller at Samuel Fox Ltd. He will speak on "Operational Research", and the President of the Institution, Mr. E. W. Hancock, will be in the chair.

Research

The following reports were made on behalf of the sub-committees of the Research Committee :-

Materials Handling. The main activity of the sub-committee during this quarter has been the organisation of the three-day Convention on "Materials Handling" at Leamington Spa, on 27th - 29th September last. The general opinion of the 120 members and visitors who attended was that the gathering had served a very useful purpose and much interesting information had been made available. The delegates were privileged to hear a stimulating address from the President of the Institution. During the Convention 11 works visits were made and the sub-committee are indeed grateful for the co-operation of firms which made this possible.

The Working Group on case studies provides one study a month for publication in the Journal and it has been interesting to note the interest roused by these. Enquiries have been received from as far afield as Belgium, Egypt and Nigeria.

The Syllabus and Examination Working Group have completed their report which has been circulated for comment to the Education, Membership and Research Committees.

Material Utilisation. Although the sub-committee have not met during the period under review, the respective panels have been working on notes for guidance for distribution to sections. Working groups are already being set up in Birmingham and Sheffield.

A short article on the work of the sub-committee appeared in the October Journal.

Sources of Information

The finishing touches are now being made to the final draft of the Directory.

Control of Quality. A new sub-committee has been set up under the Chairmanship of Mr. R. K. Grunau, M.I.Prod.E., Chief Inspector, Oil Engine Division, Rolls-Royce Ltd., and has already made considerable progress.

Joint Research Committee. No meeting of the main committee has been held during the quarter, but the two sub-committees on "Electronics and Kindred Modern Developments as Applied to Process Loading" and "The Effective Use of Shiftworking" have been very active.

Standardisation

The Council adopted the Standards Committee's recommendation that the British Standards Institution should be advised that B.S.1866, on Cutting Tool Nomenclature, should be revised. The Standards Committee had conducted an investigation into the use of this Standard by affiliated firms, which had convinced them that the present system did not meet the needs of industry.

The Standards Committee reported that two sub-committees had been set up. The first, on International Standardisation, was under the Chairmanship of Mr. T. A. C. Sparling, and the second, whose Chairman was Mr. J. A. W. Styles, would deal with Unit Heads and Platens.

With regard to the annual Conference of Standards Engineers, a meeting of the Joint Advisory Committee with the British Standards Institution had been held and arrangements were going forward for the next Conference to be held in London in May, 1957. It has been agreed that the Conference shall be a discussion meeting and a number of subjects have been put forward for consideration.

The Committee continues its work of appointing Institution representatives to serve on B.S.I. Technical Committees and of commenting on draft specifications.

Hazleton Memorial Library

It was reported by the Library Committee that the number of enquiries received was gradually increasing, noticeably since the publication of the catalogue. Many enquiries are received from kindred organisations and from firms, but the majority come from members.

Regional and Section Reports

The Council received a number of reports from Regions and Sections, extracts from which appear on pages 770 - 773.

Membership

The Council approved a number of recommendations for membership and transfer, details of which are given on pages 768 --769.

Sections Outside the United Kingdom

The Secretary reported that Mr. B. F. Goodchild, of Calcutta, had been elected to the all-India Council of Technical Education and has been elected Chairman of a group which was producing a report on management studies. He was the only European member of this very important Council.

Mr. B. H. Dyson, Past Chairman of the Research Committee, had recently visited Bombay and had had an opportunity of meeting the Section Committee and giving a brief address on Institution activities.

The Melbourne Technical College was running a course on automation in which the Institution had been asked to co-operate and had provided a panel of four members to answer questions.

Obituary

The Council recorded with deep regret the deaths of the following members :-

Members : W. G. Jenkins; E. Lilayin; G. E. Lumb; G. J. Morgan; H. Orensten; G. A. Ridgley; W. N. Roberts.

Associate Members : A. Bold; E. P. Dedman; H. O. Norwood; W. H. Phillips; W. S. Weston.

Associate : J. W. Dobinson.

Date and Place of Next Meeting

It was agreed that the next meeting of Council should be held at 10 Chesterfield Street, London, W.1, on Thursday, 31st January, 1957. It was also agreed that the Annual General Meeting of the Institution should take place on the same day and in the same place, at 2 p.m.

ELECTIONS AND TRANSFERS

25th October, 1956

ADELAIDE SECTION

Recommended
As Graduate
P. G. Kentwell.

BIRMINGHAM SECTION

Recommended
As Member
L. A. L. Brown.
As Associate Members
J. R. Alian, W. H. Knight, D. H. Salvin.
As Graduates
E. T. Holland, E. V. Hughes, T. J. Martin, N. S. Prideaux, G. V. Rosser, J. F. Hull.
As Students
J. P. Ashley, C. S. P. Shepherd.

Transfers
From Graduates to Associate Members
J. Gilbert, J. D. Radford, R. Broaderwick, E. G. Kinch, P. G. Slamer.
From Student to Graduate Member
A. G. Willis.

BOMBAY SECTION

As Associate Member
K. C. Jaitly.
As Student
S. C. Kharbanda, R. M. Palaniappan.
Transfer
From Associate Member to Member
C. Scott

CALCUTTA SECTION

As Graduates
S. K. Ray, P.O. Sharma.
As Students
P. S. Mathur.
Transfers
From Graduate to Associate Member
C. R. Datta Gupta.
From Associate Members to Members
P. L. Kumar, D. R. Sen.
From Student to Graduate Member
D. K. Pal.

CANADA SECTION

Recommended
As Graduate
G. C. May.

CORNWALL SECTION

As Graduate
W. S. Uren.

COVENTRY SECTION

Recommended
As Graduate
O. J. Nilsson.
Transfers
From Graduates to Associate Members
C. F. Bateman, W. A. Wilcock.
From Student to Graduate Member
G. Viner.

DERBY SECTION

Recommended
As Graduates
C. H. Eyre, R. Booth.
As Student
F. K. Webster.

DONCASTER SECTION

Recommenced
As Associate Member
C. P. Atwell.

EASTERN SECTION

Recommended
As Student
G. C. Hanson.
As Member
H. V. Darling.
Transfer
From Graduate to Associate Member
G. W. Pratt.

GLASGOW SECTION

Recommended
As Associate Member
G. W. Brodie.
As Graduates
W. McAlpine, R. L. Donaldson, I. Sandilands.
Transfer
From Graduates to Associate Members
A. Kirk, A. H. Poole.

GLOUCESTER SECTION

Recommended
As Graduates
R. G. Chappie, N. A. Martin.

HALIFAX SECTION

Recommended
As Graduate
G. Wilde.
Transfers
From Associate Member to Member
R. Parish.
From Graduate to Associate Member
K. J. Foster.

LEICESTER SECTION

Recommended
As Associate Members
W. E. Bradshaw, B. A. Coote.
As Graduates
B. Nagchaudhuri, D. Sahai, K. A. Sahgal.
As Students
G. R. Mee, R. J. D. Franklin, L. K. Reeve, J. Sherman, M. F. Williams.
Transfers
From Graduates to Associate Members
F. J. Foinquinos, E. A. Rice, W. T. Tory, R. F. Wholton.
From Associate Member to Member
S. H. Trott.

LINCOLN SECTION

Recommended
As Graduate
S. Futayyah.
Transfer
From Graduate to Associate Member
S. A. Rudd.

LIVERPOOL SECTION

Recommended
As Member
J. Burns.
As Graduates
R. Owen, D. Staig, R. H. Gregg.
Transfers
From Associate Member to Member
D. Gemmell
From Graduate to Associate Member
E. A. Hewitt, K. Hall, H. E. Jones.
From Students to Graduate Members
E. J. Crompton, J. S. Steele.

LONDON SECTION

Recommended
As Member
T. C. Lowrie.
As Associate Members
W. T. Collins, W. L. Dickson, W. G. L. Dorkings, R. W. Mayhew, J. Robertson.
As Graduates
R. F. Popperwell, J. R. Rebello, S. Richardson, J. E. Storey, J. B. Gooderson, B. E. Jackson, N. A. Nagle.
As Students
H. Baxter, A. Campden, M. H. Denny, D. E. Rattray, T. H. Whittle.
Transfers
From Graduates to Associate Members
R. A. Foley, J. E. Hyams, E. J. Rice, L. H. Sanders, A. G. Thomas, H. Bibring.
From Associate Members to Members
C. H. Starr, H. E. Tickner.
From Student to Graduate Member
W. T. File.
From Graduates to Associate Members
H. F. Box, J. L. H. Girling.

LUTON SECTION

As Associate Member
R. D. Knight.
As Student
N. F. Higgins, R. E. Stone.
Transfers
From Graduates to Associate Members
A. Emmett, R. A. S. Sibley.

MANCHESTER SECTION

Recommended
As Associate Members
J. W. Saunders, N. Taylor.
As Graduates
D. Brownlie, R.T. M. Kinsey, R. Wright.
As Student
T. Harper.
Transfers
From Graduates to Associate Members
T. Brown, E. R. Higham, F. Renwick, G. A. Winterburn.
From Student to Graduate Member
R. Stone.

MELBOURNE SECTION

Recommended
As Graduate
R. B. Normand.

NORTH EASTERN SECTION

Recommended
As Graduate
J. S. Robinson.

NORTHERN IRELAND SECTION

Recommended
As Member
D. W. P. Woods.
As Student
R. Wilson.

NORWICH SECTION

Recommended
As Associate Member
W. H. Holmes.

NOTTINGHAM SECTION

Transfers
From Associate Members to Members
H. Buckton, B. A. Green.
From Graduates to Associate Members
D. A. W. Leech, J. Mills, D. K. Wood.
From Student to Graduate Member
R. F. Wheelhouse.

PETERBOROUGH SECTION

Recommended
As Students
T. A. Hinch, B. K. Wilkinson.
Transfer
From Associate Member to Member
L. P. Simpson.

PRESTON SECTION

Recommended
As Associate Members
H. Beeley, N. A. Butterworth, A. W. Johnson.
As Graduates
R. Rainford, J. L. Bland, C. Boughton, H. Fletcher, W. A. Norris, W. H. Sutton.
As Student
T. R. Hallmark.
Transfers
From Graduates to Associate Members
S. Armstrong, H. Kellett, R. Lambert, E. K. Langham, E. Wilkinson.
From Students to Graduate Members
I. C. Campsie, B. Lee, S. Wright.

ROCHESTER SECTION

Recommended
As Students
D. R. Gaskin, P. N. Leaver, J. J. Patty.
Transfer
From Graduate to Associate Member
H. F. Watts.

SHEFFIELD SECTION

Recommended
As Graduate
C. Jones, F. Marshall.
As Students
K. M. Walker, N. Vollans.
Transfer
From Graduate to Associate Member
R. D. Sawtell.

SHREWSBURY SECTION

Recommended
As Associate Member
H. Rothwell.
As Student
M. J. Parker.

SOUTH ESSEX SECTION

Recommended
As Associate Member
W. J. Edmonds.
As Graduates
T. C. Carter, M. L. Robinson.
As Students
M. J. S. Hassell, R. J. Vaughan.
Transfers
From Graduates to Associate Members
H. Clements, D. Coates, G. V. Wood.
From Students to Graduates
W. Bruce, T. R. Gulliver, B. B. J. Smith.

SOUTHERN SECTION

Transfers
From Graduates to Associate Members
E. J. A. Rayment, M. H. Choules.
From Students to Graduates
M. Ahmad, S. Z. H. Jaffri, W. H. Khan.

SOUTH AFRICA SECTION

Recommended
As Graduate
A. S. Rachman.

STOKE SECTION

Recommended
As Associate Member
J. M. Keegan.

SOUTH WALES SECTION

Transfer
From Graduate to Associate Member
C. L. Griffiths.

SYDNEY SECTION

Recommended
As Associate Members
A. V. Gibson, S. H. Keable.
As Graduates
D. A. King, J. F. Treloar.
Transfer
From Graduate to Associate Member
R. W. Green.

TEE-SIDE SECTION

Recommended
As Student
C. Robinson.

WESTERN SECTION

Recommended
As Associate Member
I. R. Smith.
As Graduate
A. Smith.

WEST WALES SECTION

Recommended
As Student
V. J. Borsden.
Transfer
From Student to Graduate Member
D. F. Reeves.

WOLVERHAMPTON SECTION

Recommended
As Associate Member
P. Titmuss.
As Graduate Members
G. Rogers, S. G. Bull, W. P. Mirtle.
As Student
A. B. Caine.
From Graduates to Associate Members
H. Bainbridge, E. J. V. Connelly, D. McCorquodale, F. Mitchell, A. J. Webberly.

WORCESTER SECTION

Recommended
As Graduates
W. T. Hawkley, E. R. Johnson.
As Student
B. R. Willis.

YORKSHIRE SECTION

Recommended
As Graduates
T. W. Howgate, P. Scott, B. Bamforth, C. R. Hewitt.
Transfers
From Student to Graduate Member
A. R. Rowland.
From Graduates to Associate Members
J Dyson, D. Treasurer, C. Cussans, G. Gledstone.

NO SECTION

Recommended
As Member
M. M. Calonier.
As Associate Member
G. F. Micheletti.
As Graduates
D. J. King, W. T. Whitfield.
As Student
N. F. Amin.
Transfers
From Students to Graduates
J. C. Holst, P. Uawithya.

EXTRACTS FROM REGION AND SECTION QUARTERLY REPORTS

EASTERN REGION

Eastern Counties

After holding two very successful evening visits to local firms, the Committee found difficulty in obtaining sufficient support for the proposed day visit to London Airport during September and this was reluctantly cancelled.

The winter programme of lecture meetings has now been completely planned by the Section Committee and several applications for membership have been discussed.

In addition to the usual six lecture meetings, it is hoped to arrange an extra meeting during April next, this to be held in Cambridge.

Norwich

During the last quarter interest in the Section has been stimulated by two most interesting works visits. The first was at the invitation of Mr. G. S. Howell, M.I.PROD.E., Chief Engineer, Mackintosh Caley Ltd. This tour was most interesting and informative to the 30 members who attended.

The second visit, at the invitation of Mr. W. A. Pitt, A.M.I.PROD.E., Manager, Metamec Ltd., Dereham, gave 30 members an opportunity of touring a modern clock factory.

The Section has been fortunate, this year, in being able to secure lecturers of first choice for their meetings which, it is anticipated, will be very well attended and in view of this, increased accommodation has been reserved.

EAST AND WEST RIDINGS REGION

Sheffield

In the quarterly report for June, mention was made of the correspondence between the Committee and the College of Commerce and Technology concerning the need for a special course on various statistical methods used in industry. It is gratifying to record that the College had already recognised the value of such a course and were preparing the details. This course is an introduction to the subject of statistics as applied in industry and is intended for persons engaged in production distribution or accountancy, who may find in the techniques described, aids to solving problems connected with their work. The Section Committee trust that members will take advantage of the facilities offered and encourage the College to develop the course.

Members of the Section who were interested in forming a Working Group to assist the work of the Institution's Sub-Committee on " Material Utilisation " have arranged a meeting for September 26th, when the Chairman will outline the objects and terms of reference. It is expected that some useful case studies will be forthcoming.

The new session officially opened with the Annual Dinner, held in October, when the Section was honoured by the presence of Mr. E. W. Hancock, the President of the Institution, and Sir William Stanier, F.R.S., President of P.E.R.A.

MIDLANDS REGION

Birmingham

The Section programme for the 1956/57 Session got away to a good start and the demand for tickets exceeded the capacity of the Section's local meeting place. Thanks are due to the University of Birmingham for making the Mason Theatre available to the Section, enabling the proceedings to be presented on two evenings to over 400 members and friends. The assembly heard Mr. J. L. Wessolowski, A.S.M.E., of Milwaukee, give his views on "Automation" and Herr W. Weidmann answered questions on recent developments by Germany in the design and application of transfer machines. The programme included some of the latest films by The Ford Motor Co. and The Kearney & Trecker Corp., U.S.A., and Karl Huller G.m.b.H., Germany.

The next meeting will feature "Safety" and will be presented by Messrs. Silver and Hillier who will deal with it as seen by the Production Engineer and by H.M. Inspector of Factories, and should prove to be an evening of intense interest.

The Section is planning to hold a One-Day Conference in late Spring of 1957 with the theme "Tooling To-morrow's Production". This will be a comprehensive affair and members will be able to select a series of specialist lectures to suit their own particular interest.

Birmingham Graduate

During the summer months the Section Committee have been fully occupied in arranging the Conversazione held at the Birmingham University early in September. This function was well attended and brought together members and visitors from many parts of the Midlands.

The theme for this Conversazione was "Automation" and the opening address was given by Dr. N. A. Dudley, PH.D., B.SC., M.I.PROD.E. This was followed by Mr. G. A. Emery's paper on "The Trend in the Use of Electronics in Control Gear". Next a combined paper given by Mr. F. T. Dean, M.I.MECH.E.,M.I.PROD.E., and Mr. F. J. Tuffley, on "Motivation—The Application of Pneumatic and Hydraulic Devices". The final paper given by Mr. D. R. Eaves, M.I.PROD.E., was entitled "Machine Tools and their Influence on Industry". After each paper two films were shown on the latest and up-to-date transfer machines in America.

After summing up the Conversazione Mr. B. G. L. Jackman, M.I.PROD.E., Chairman of the Midland Region, thanked the speakers and members of the Senior Committee for their assistance in helping the Graduates to hold the function, also Professor G. F. Mucklow, D.SC., M.I.MECH.E., for the use of the new Mechanical Engineering Building at the University.

In November the Birmingham Section will be holding a lecture meeting in Kidderminster; this has been arranged with the view making the Institution's activities more widely known to people outside the main industrial areas, also to enable members in that area to attend a lecture meeting.

Social events for the coming session include a possible visit to the I.T.V. Television Studios in Birmingham. A Christmas Dance is to be held on the 20th December.

Coventry

As usual during the summer months, there was little Section activity, although the Committee met regularly and, amongst other things, completed an interesting lecture programme for the 1956/57 session. In June, the Committee members and their ladies enjoyed a pleasant evening at the Greswold Hotel, Knowle.

The first meeting of the new session, attended by over 120 members and visitors, took the form of a sound film "The Development of German Transfer Machines", presented by Messrs. Karl Huller, Ludwigsburg, Germany, and shown by the courtesy of Messrs. Burton Griffiths. The film was of such a high standard, both for content and presentation, that the discussion which followed was a little slow; however, quite a number of questions were competently answered by Mr. Weidman, European Technical Representative of Messrs. Karl Huller.

Coventry Graduate

All the necessary arrangements concerned with the forthcoming lecture programme have now been completed. Once again every endeavour has been made to cater for a variety of interests and it is hoped that the meetings will meet these requirements.

In September a film evening was held followed by a Production Panel in October. In November Mr. J. Silver of Jaguar Cars Ltd., will speak on "Factory Layout and Planning with Special Reference to the Production on Jaguar Cars" and in December it is proposed that another film evening will be held.

In the New Year the first talk will be by Mr. L. J. Hoefkens of the Lockheed Brake and Hydraulic Co. Ltd., on the subject of Materials Handling, and the final lecture meeting will take place in March and will be on "The Production from Bar Stock" by Mr. R. Jackson of Wickman Ltd.

Three Works Visits have been planned for the session, the first having taken place in September when an evening visit was made to the Co-op. Bakery, Coventry. The second is a day visit to The Standard Motor Co. Ltd., Coventry, for the purpose of

seeing all the latest transfer lines and equipment to be installed and finally there is to be a Saturday morning visit to Messrs. Stewart & Lloyds Ltd., of Birmingham.

A Treasure Hunt was held in September followed by the Coventry Section Dinner Dance in October. In the latter instance, the Graduates are indebted to the Senior Section for allowing them to attend the function at a much reduced price.

It will, of course, be realised that in order to arrange such varied activities, it is very necessary for each Committee member to play an active part in the affairs of the Section. The Section counts itself extremely fortunate to have such a Committee and are grateful to the members for their support at these many functions.

Shrewsbury

The 1956/57 year has been inaugurated by a visit of members and friends to Carpet Trades, Ltd., Kidderminster. A well-organised tour of the works proved both interesting and instructive. The works visit was followed by a late Dinner at the Park Attwood Hotel, so rounding off a successful evening.

The first lecture in September was on the subject of "The Practical Application of Job Evaluation", given by Mr. E. H. Collins.

Wolverhampton

The first lecture of the 1956/57 session was held in October when Mr. E. Heys spoke on "Electronic Control in Industry". Meetings have been arranged for each month up to and including April and the Committee look forward to an interesting series of lectures.

The Section will be privileged once again in having the Regional Meeting in Wolverhampton in December, when it is anticipated that the first rate co-operation existing between Sections in the Midland Region will make this occasion as highly successful as last year.

The Committee are delighted that Mr. E. W. Hancock, M.B.E., in his Presidential year of office has been able to accept an invitation to attend a Dinner in his honour. Arrangements are going forward for this function to be held in January, 1957, at the Mount Hotel, Wolverhampton.

NORTHERN REGION

North Eastern

During the summer months Mr. W. F. S. Woodford visited the North East and on the evening of his departure, the Regional and Section Chairmen together with a number of Committee members joined Mr. Woodford in Durham.

The 1956/57 Session was opened by the new Chairman, Mr. H. B. Topham, with a most interesting address in which he stressed the importance of the craftsman and his attitude towards his craft and the necessity of good leadership in every organisation. The address was followed by a new and very interesting film presented by the Chairman, the title of the film being "Parsons, the Genius of Power".

The programme for the session has been carefully arranged and the Committee are pleased to record that the majority of the papers are new and have been obtained within the area of the Section. In addition, the sequence of the papers has been chosen to provide continuity but nevertheless, the subjects covered include Materials Handling, Metallic Tubes, Turbine Blading, Management and Production Control in the U.S.A.

NORTH MIDLANDS REGION

Arrangements are now being made for the second Day Conference to be held in this Region in the early part of June next year. The date and place has yet to be finalised and the next Regional Committee meeting will be fixed when definite promises have been received from one of the four Sections in this Region, excluding Peterborough.

Apart from the Day Conference it is hoped to maintain some Regional activity in this area and it was only because of the success of the Peterborough Conference this year that this effort is being repeated.

Leicester

The activities of the Section during the period under review have been confined in the main to meetings of the Committee.

The 1956-1957 lecture programme has been prepared and it is hoped the interesting series of meetings will result in increased attendances.

This year's Section Annual Dinner will be held in November at the Grand Hotel, Leicester. Guests will include: The Lord Mayor of Leicester; Mr. E. W. Hancock, M.B.E., President of the Institution; Mr. C. H. Wilson, M.A., Principal of University College, Leicester, together with leading industrialists and educationalists of the city.

Lincoln

Owing to the holidays coming during the last quarter, there is little to be said about the activities in this Section.

The programme for the coming winter session has been so arranged as to cover the Northern part of the county and owing to the generosity of the Grantham Engineering Society the southern part will also be covered. If the attendance at the meetings arranged for the coming session reach the number achieved last, it is felt sure that the lectures will receive a good welcome.

Lincoln Section have arranged for their fourth Annual Dinner-Dance to be held at the Ruston Club, Lincoln, in November.

Nottingham

As stated in the last report there has been no Section activities during the months of July and August. The session opened with a visit to the Anchor Street works of Euston and Hornsby Ltd., when those attending were provided with facilities for the study of production methods employed in the manufacture of gas turbines. There was much to be found in both the machine and erecting shops that was of interest to members.

Mr. C. T. Butler, A.M.I.MECH.E., M.I.PROD.E., Head of Engineering, Nottingham and District Technical College, has been appointed corresponding member to the Hazleton Memorial Library Committee.

The Section has made a small contribution to the request of the Material Utilisation Sub-Committee by submitting case studies and more studies have been promised.

Peterborough

At the beginning of the last quarter Mr. W. Peck took over his new duties as Section Chairman. Tribute was paid to the retiring Chairman, Mr. H. G. Adams, for the excellent manner in which he has carried out his duties for the past two years.

The first activity of the winter programme was held in September when a party of production engineers and their wives visited The British Thomson Houston Glassworks at Chesterfield.

The party was conducted on a most interesting and enjoyable tour of the factory and special thanks are due to the management and staff of B.T.H. Ltd., for the excellent arrangements made; also for their kind and generous hospitality.

After lunch the party visited Chatsworth House and Gardens and spent an enjoyable afternoon before journeying on to Matlock Bath for tea then returning home via Nottingham.

NORTH WESTERN REGION

Arrangements are now complete for the Regional lecture which is to be held this session in the Great Hall at Manchester College of Science and Technology, in April, 1957. The subject is "Human Relations in Industry", the Paper to be given by Mr. J. H. Brebner, Public Relations Advisor to the British Transport Commission.

Final arrangements are now in hand for the Regional Dinner. Mr. H. G. Gregory, Chairman of Council, and the Lord Mayor of Liverpool and the Lord Mayor of Manchester have accepted invitations.

Liverpool

The results of the lecture programme questionnaire sent at the beginning of this year to all Section members were, as anticipated, rather disappointing; nevertheless approximately one-fifth of the membership replied. On the assumption that this is the active membership which must be satisfied, the type of lecture programme requested was carefully studied and it is felt that this has yielded information of value. Nearly all the members requested lectures which would be of use to them in their present situations and with this in mind the Committee have chosen a programme which they trust will suit the majority of industries in the area .

Manchester

The lecture programme for the 1956-57 session is now completed. The first lecture held in September was entitled "CO_2 Process Applied to Core Making" and was given by Mr. A. Talbot, M.I.B.E. A lively discussion on practical problems associated with this process followed an excellent lecture.

Arrangements are now complete for the second Annual Social Evening, organised for the members of the Committee and their wives, to be held this year in October.

The Section welcomes Mr. R. E. Mills, M.I.PROD.E., who is elected to serve on the Senior Committee, and Mr. L. E. Chadderton, GRAD.I.PROD.E., GRAD.I.MECH.E., Chairman of the Graduate Section, who is elected as Graduate representative on the Senior Committee.

Manchester Graduate

The complete programme for the above Section will now consist of lecture meetings, the Annual General Meeting, and a series of works visits at about six week intervals.

During the coming session the Graduate Committee intend to invite to their Committee meetings members of the Section who attend the lectures, so that these members will have a chance to show greater interest. Members of the Graduate Committee will also attend the Senior Committee meetings with the Graduate Chairman or Secretary.

Mr. Murphy has taken over the position of Visits Secretary from Mr. Jones, who has had to resign due to pressure of business.

Preston Section

The lecture programme for the winter session is now complete, five lectures being arranged in addition to the Joint Regional lecture.

As usual the Section are co-operating with local Productivity Committees, the first lecture being arranged in collaboration with the Preston Productivity Committee. This lecture entitled "What Automation Means" is to be given by Mr. F. G. Woollard, M.B.E., M.I.MECH.E., M.I.PROD.E., M.I.I.A., M.S.A.E., and will take place in October, at Preston.

The second lecture, entitled "Special Purpose Unit Head Machines", is to be given by Mr. T. W. Elkington, M.I.PROD.E., in November and in January a second visit will be paid to the Accrington College of Further Education for the lecture on "The Manufacture and Application of Ball and Roller Bearings" by Mr. R. W. Jones. The Committee feel that these links with colleges catering for production engineering students are beneficial to all concerned and thanks are due to the Principals of the two Colleges for their ready co-operation in granting facilities.

Mr. W. L. Jones, M.I.PROD.E., General Works Manager of Goss Printing Company, Preston, has been appointed Vice-Chairman and Chairman-Elect of the Section and is undertaking the duties of the Chairman whilst the present Section Chairman is away on a business trip to India and Australia on behalf of Leyland Motors Ltd. The Chairman, Mr. F. Grimshaw, O.B.E., M.I.PROD.E., is expected to be away for two or three months.

SOUTHERN REGION

Oxford

The lecture programme for the 1956-1957 session with a general theme "Materials" now includes a joint meeting on the subject of material control with the local branch of the Institute of Cost and Works Accountants.

Fresh ground will be broken by holding a lecture meeting at Aylesbury in November.

The Southern Regional social visit to Oxford in September attracted about 40 members and friends. After lunch a tour was made of some of Oxford's famous colleges, including New College, Christ Church and Merton College. In spite of rather inclement weather the visit proved most enjoyable and tea concluded a successful event.

Reading

A most successful works visit was made by a party of 20 members to the British Railways Works, Swindon. The Committee are most appreciative of the steady support that is given to these all-day visits that are arranged each year.

Reading Section were able to provide a good proposition of the members and families of the party that visited the Oxford Colleges in September, organised by the Oxford Section for the Southern Region. The visit proved to be most interesting and enjoyable.

Mr. J. M. George, a member of the Committee, has kindly agreed to be a corresponding member for the Hazleton Memorial Library Committee.

This session's lecture programme is following previous patterns of holding lectures in different parts of the Section, i.e. Reading, Basingstoke and Staines. This policy can be recommended to Sections who may be thinking along similar lines.

Southern

The Southern Section Committee met again in September to discuss finally their winter programme which commences with the opening lecture in October in conjunction with the Institute of Plastics and includes the Fifth Aircraft Conference in January, 1957, and the Annual Dinner-Dance in March, 1957.

As in other years emphasis is placed on joint lectures with other societies, such as the Royal Aeronautical Society, Institute of Industrial Administration, Institute of Plastics, Association of Supervising Electrical Engineers, but it is regretted that the Institute of Cost and Works Accountants do not feature in the programme this winter.

It is regretted that owing to lack of support no lectures will be held at the Isle of Wight—but it is expected that the aircraft lecture to be held at Christchurch in December will be a huge success.

SOUTH EASTERN REGION

Luton

During the quarter under review, the Section has principally made preparations for the 1956/7 lecture programme. The session began with a lecture by Mr. H. W. Merritt entitled "Vitreous Enamelling of Domestic Cooking Appliances". It proved to be extremely interesting, but possibly because it was an unusual subject for production engineers, attendance was poor.

The remainder of the programme is devoted to "Automation" and it is hoped that the Section membership will endeavour to give it maximum support.

Attention is drawn especially to the joint meeting with the Eastern Branch of the Institution of Mechanical Engineers in October, when the subject will be "The Financial Aspects of Automation", presented by Mr. J. Mostyn. It is hoped that a special effort will be made to make this meeting truly successful one, particularly in the matter of attendance.

SOUTH WESTERN REGION

Cornwall

There has been very little activity in the Section during the summer as is usual in Cornwall.

The Committee, however, have met on several occasions, and a very attractive programme has resulted from their efforts. This programme will commence in October.

Arrangements are almost complete for the second "Compressed Air as an Aid to Greater Productivity" Conference to be held at Camborne at Easter, 1957, under the auspices of the Section. It is hoped to make the Conference a popular biennial event within the Section. Details of the programme will be available shortly, and it is felt that many members will desire to combine business with pleasure and visit Cornwall next Easter.

Western

The 1956 Viscount Nuffield Lecture is to be held at the Engineering Faculty of Bristol University and it is expected that there will be a full house.

Although somewhat apprehensive regarding the applications for membership, it is interesting to note that more students are taking the Production Engineering Course at the Bristol College of Technology this year than ever before, and they come from a variety of firms, and whilst this portends well for the future, the Section still view the immediate position with some concern.

Western Graduate

The Section ended its 1955/56 programme with a visit to a local printing works, followed by a visit to the water works. Both visits proved to be very interesting and were fairly well attended.

The 1956/57 lecture programme has now been completed and includes Methods Engineering, Fibre Glass Mouldings and Glass Production. The Committee hopes that the programme will meet with the approval of the Sections and be well attended.

Although the Section has suffered the temporary loss of its Chairman, who is engaged on a course at P.E.R.A., they have gained several new members, one of whom is Mr. R. U. Shaw, ex-Hon. Secretary of the London Graduate Section. The Committee extends its best wishes for a speedy recovery to Mr. J. Ford, who recently entered hospital.

SCOTTISH REGION

Dundee

The Dundee Section Committee have prepared what they consider to be a very interesting and instructive syllabus of lectures for the ensuing winter session. The Committee now depend on the members in the area to support and encourage their efforts by attending.

The opening lecture was given by Mr. W. P. Kirkwood, B.SC., M.I.MECH.E., M.I.PROD.E., who dealt with the problem of "Materials Handling with Special Reference to Batch Production". Mr. Kirkwood delivered a splendid lecture. He dealt principally with medium weight articles, many of which had awkward shapes. He showed in turn the advantages to be gained by the use of a few types of standard containers and adapting them. The advantages and disadvantages of a variety of transporters, together with their labour problems; lifting and transport by tackle and crane; and methods of co-ordinating the whole handling problem.

The discussion time revealed that many firms in the area were active on this problem and their representatives were able to have their questions answered by Mr. Kirkwood from his wide knowledge and experience of the subject.

Edinburgh

The Edinburgh Section opened their Winter Session in the North British Hotel, Edinburgh, with a Film Evening to which ladies were specially invited. It is now over two years since the Section had an evening thrown open to the ladies and it was most gratifying to find that it met with a good response.

Films were obtained from E.D.A., with a bias towards the use of electricity and labour-saving devices in the home, and these were well received.

After coffee the company were further entertained with films of a lighter nature, dealing with Scotland's Highland Development Schemes and a Scottish character story. A lively interest was maintained throughout the whole evening.

The October meeting was a joint meeting with members from the Institute of Welding. The speaker on this occasion was Mr. J. A. Dorrett, A.H.W.C., M.I.E.E., M.I.WELDING, and his subject was "Welding and Marine Engineering".

SECTIONS OUTSIDE THE UNITED KINGDOM

Adelaide

In June, Mr. J. Allen Obenstone, B.SC., gave a well-prepared explanation of the operation and use of digital computers for industry. All those present appreciated the clarity of presentation. At the July meeting films of European machine tools, boring mills and modern lathes were shown. The August lecture was given by Mr. G. C. Tate, of the Vacuum Oil Co., on "How Lubrication Can Affect Maintenance Costs".

Australian Council

Messrs. Clark, Penny and Hemer represented Adelaide at the Melbourne meeting in June. The Adelaide Section combined with the Australian Institute of Management and Institute of Cost Accountants in a series of two meetings on "Electronics for Business and Industry". Films, discussions and a demonstration of an electronic multiplying punch provided much new and valuable information.

The Education Committee Chairman, Mr. W. Gwinnett, is making a visit to the United Kingdom.

Melbourne

At the June meeting 80 members attended to hear a lecture entitled "New Abrasives—New Grinding Techniques" by Mr. K. McIndoe. Mr. McIndoe presented in his lecture many new grinding methods which he had experienced overseas. At the July meeting a Paper entitled "Modern Carbide Techniques and Application" was presented by Mr. W. J. Kelsey, A.M.I.MECH.E., A.M.I.PROD.E., 77 members attended. The Paper covered development of tungsten carbide, manufacture within the Commonwealth, Australian standards of tipped tools and tool manufacture and applications.

At the August meeting, 67 members attended to hear a lecture entitled "Compressed Air, Uses and Applications". This was presented by Mr. A. E. Elliott, who flew from Sydney to present this lecture which covered the various types of pneumatic equipment now available to the production engineer.

Melbourne Graduate

During the quarter under review two evening works visits were held which were attended on each occasion by about 20 Graduates and Students. In July, the visit was made to the production plant of Electrolux, Ltd., the well-known manufacturers of cleaners and refrigeration equipment. After a discussion with the General Manager regarding the Company's planning and progressing of work and the production control methods used, the group were conducted through the various sections of the plant. A most interesting evening was experienced by all members.

The August visit was to the Machine Tool Works of McPherson's Ltd. This company is producing high grade lathes covering a wide range of capacities and tool and cutter grinders. The group was given adequate time to follow through the production of the machines from rough castings to final assembly, and were very interested in the slideway grinding machines used in grinding on the lather bends. The visit concluded in the Production Office where the works Manager explained his Company's production control methods. The visit was most informative.

In September a visit is planned to Radio Corporation Ltd., makers of radio, television and electronic equipment.

New Zealand

In June a very interesting and informative group discussion was held on "Mould Production, Cavity Hobbing and Die Sinking", illustrated with samples of work from members. In July members and friends paid an interesting evening visit to the New Zealand Glass Manufacturers Company in Auckland, where normal production of glassware and plastics was in progress. This also proved most interesting and instructive, particularly in regard to the toolroom operations.

The Reference Library has now been inaugurated in a small way, with hopes in the future of a steady increase in the number of volumes and the scope of its activities.

Two Committee meetings have also been held during the quarter.

Sydney

Professor D. M. Myers gave a most interesting and topical lecture in May entitled "Arithmetic to Automation". He traced the development of digital computing machines and explained the application of the techniques and principles used in the solution of industrial control problems. The lecture was well attended and a most stimulating discussion followed. The June lecture was given by Mr. A. J. Kemp on "The Metallurgists' Place in Production Engineering".

This year's Papers have covered a very wide field of topics of general interest to members, and the July Paper on "Television" by Mr. J. E. Bailey attracted a large audience, especially as it expected that the first television station will be operating this year.

The Education Committee has met regularly to discuss the formation of a seven-year part-time degree course.

The monthly Committee meetings have been well attended, and all the Committee members who have been overseas have now returned. Unfortunately, owing to pressure of business none of them was able to visit headquarters.

Graduates Conversazione on Auto-motion

On Saturday, 8th September last, the Birmingham Graduate Section of the Institution held a one-day Conversazione on Auto-motion at the University of Birmingham, by kind permission of the Governors. The purpose of the Conversazione was to bring to the notice of members of the Institution the advance being made to-day in the application of electronics, hydraulics and pneumatics in the field of automation.

Over 150 Graduate and Student members gathered under the chairmanship of Mr. A. C. Turner, G.I.Mech.E., Grad.I.Prod.E., to hear specialised papers given by acknowledged experts in the selected field. An address of welcome was given by Dr. N. A. Dudley, B.Sc., M.I.Prod.E., Head of the Department of Engineering Production, University of Birmingham, who outlined the part being played by his Department in preparing engineers to take their place in managing the new phase of automation production.

The meeting then heard Mr. G. A. Emery, B.Sc., A.M.I.E.E., of the Igranic Electric Company, give a Paper on "The Trend in the Use of Electronics in Control Gear". This was followed by a joint Paper given by Mr. F. T. Dean, M.I.Mech.E., M.I.Prod.E., of Geo. W. King, Ltd., and Mr. S. J. Tuffley, of Lang-Pneumatic, Ltd., on "Motivation—The Application of Pneumatic and Hydraulic Devices".

The afternoon session was devoted to a Paper on "Machine Tools and Their Influence on Industry", by D. R. Eaves, M.I.Prod.E., of The Standard Motor Company, who outlined some of the major problems that occur when a large car manufacturer decides to install automatic equipment. The proceedings were summed up by Mr. B. G. L. Jackman, M.I.Prod.E., Midlands Region Chairman, who stressed the value of such meetings where engineers could speak freely and enjoy such good company.

The subjects discussed were well illustrated by coloured films loaned by the Kearney & Trekcer Milwaukee Corporation, and by slides loaned by The Standard Motor Company.

Mr. Robert Appleby, Member, has been appointed Managing Director of Black and Decker. Mr. Appleby joined the Company in 1953 as a Director, and later that year was appointed Director and General Manager. For a time he held the post of Chief National Capacity Officer at the war-time Ministry of Production, and in 1943 he joined Ascot Water Heaters as Works Manager. Mr. Appleby served his firm until 1952 when he relinquished his position as General Manager, and also the General Managership of Nash and Thompson, having held these two appointments concurrently since 1948. In 1943 he was awarded the Institution Medal for the Best Paper by a Member. Mr. Appleby is a founder-member of the British Institute of Management.

Mr. W. E. Jeffries, Associate Member, has been appointed to the Board of British Paints (Caribbean) Limited, Port of Spain, Trinidad, B.W.I. He was formerly Chief Engineer of the British Paints Limited, Newcastle-on- Tyne, England, prior to his secondment to the B.W.I. in May 1953 to build and equip the Trinidad. unit of the Organisation He was appointed General Manager in Trinidad in November 1953.

Mr. F. Landmann, Associate Member, has relinquished his appointment as Production Manager with Messrs. Mitchells, Ashworth, Stansfield & Co. Ltd., Rossendale, Lancs., and has taken up an appointment as General Manager with E.F. Electric Limited, Watford.

Mr. P. S. McCaig, Associate Member, has relinquished his position with Alfred Herbert (India) Limited, and has now taken up an appointment with Messrs. Ex-Bell-O-Corporation, Detroit, Michigan, and at the present time is spending periods in their various plants in the country before joining their Sales Organisation.

Mr. J. W. Powell, Associate Member, has relinquished his position as Assistant Works Manager of Universal Jig & Gauge Company, to become Works Manager of Porter Prototype Engineering Company, Birmingham.

Mr. J. Taylor, Associate Member, has relinquished his appointment with Holset Engineering Company Limited, and has now taken up the appointment of Production Controller with Messrs. Churchill Redman Limited, of Halifax.

Mr. W. Edwards, Graduate, has now relinquished his position with Decca Radar Limited, and is now employed by Edward Pryor and Son Limited, Sheffield.

Mr. K. Ghatak, Graduate, has left Burn & Co. Limited, Howrah, and has taken up a position with Washington University, St. Louis, as an Assistant in the Mechanical Engineering Department.

Mr. R. D. Saha, Graduate, has left his position with Briggs Motor Bodies Limited of Dagenham, and is now a Student at the University of Manchester and has taken up a post-graduate diploma course in Industrial Administration.

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